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ABSTRACT

The eleven papers of which this proceedings is composed are separated into the five sessions of the symposium. Session I contains one paper concerned with the state-of-the-art which gives a definition and overview of information science education. The three papers in the second session, theoretical approaches, are addressed to the question of what the philosophical problems underlying education in information science are. Session III is composed of four papers on practical approaches which includes the relationship of the curriculum to theoretical issues and integration of the curriculum. Curriculum development is the subject of Session IV, which contains two papers on models, techniques, implementation and cooperation. The final session contains the wrap-up paper. Brief annotations of the papers are included in the table of contents. (Author/NH)

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DIRECTIONS IN EDUCATION FOR INFORMATION SCIENCE

(1)

PROCEEDINGS OF A

SYMPOSIUM FOR EDUCATORS

Edited by
Edmond Mignon

Cosponsored by

The American Society for Information Science

The Information Science and Automation Division
and the Library Education Division
of the American Library Association

The University of Denver, Graduate School of Librarianship

Denver, Colorado, November 11-13, 1971

Prepared by
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F O R E W O R D

This publication represents a different approach to the format of documents primarily intended for dissemination and use as microfiche.

The Proceedings consists of 11 papers covering four areas and a wrap-up session. These papers will be spread over three microfiche: Fiche I will contain frames 1 through 58; Fiche II will contain frames 59 through 128; and Fiche III will contain frames 129-177.

Our original intention was to make these Proceedings available as quickly and economically as possible, which would mean strictly microfiche. However, we recognize the inconvenience to the reader when sitting at a table reading microfiche in a rigid, less natural position than when reading a book. On microfiche it is difficult to locate particular papers in a proceedings volume covering many topics. One has to scan every frame until he has reached the paper of interest. In addition, the page numbers are difficult to read on microfiche.

For these reasons we have written brief abstracts to each paper in the Table of Contents, so that the reader can easily see which papers he would like to read. We have used oversized numerals on top, right hand corner of each page, in order to facilitate the identification of page and frame number. If this approach is well received, it will represent a new trend for the Clearinghouse in the dissemination and availability of documents. We would appreciate comments on this approach from the readers.

I would like to thank Miss Sally Maury and Miss Nancy Helmuth of the ERIC/CLIS staff for their fine assistance in putting these Proceedings together.

J.I. Smith
Associate Director
ERIC Clearinghouse on Library and Information Sciences
(American Society for Information Science)

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I N T R O D U C T I O N .

Edmond Mignon
Education Committee, ASIS.
School of Librarianship
University of Washington

In January 1971 the Committee on Education for Library Automation (Information Science and Automation Division/Library Education Division) of the American Library Association proposed that a three day workshop for library and information science educators be held in the fall of 1971. The American Society for Information Science and the Association of American Library Schools were invited to share in the planning and operation of the suggested workshop.

Response was prompt and encouraging: the Education Committee of the American Society for Information Science suggested that the workshop be held as a post-conference symposium, following the ASIS Annual Meeting at Denver in November 1971, and by the beginning of April an ad hoc Planning Committee had met to work out the details of the proposal. The Committee drafted a working paper, in which it identified four major categories of schools with programs or courses in information science.

1. Library schools. This category includes those library schools with separate departments or programs in information science.
2. Information science programs. These are programs which are heavily oriented toward the theoretical aspect of information science and information handling.
3. Computer science programs. These courses are hardware- and engineering-oriented.
4. Other. Many disciplines, especially in the social sciences, are aware of information science as it relates to their area, and include courses in information science in graduate programs. Examples are psychology, communications, and business programs.

The Committee went on to observe that

> Little effort has been made to integrate the needs of each of these areas into the information science curricula. Curriculum development projects remain isolated in their sponsoring institution or professional society. With the changes in the economic situation, the straight information science and computer science programs are beginning to look toward librarianship as one area of application of the theoretical curricula; they are beginning to include bibliographic and other "applied" courses in their programs. Library schools continue to integrate systems design and information science courses into the programs leading to the master's degree in library science. There are certainly differing needs in these various disciplines or orientations. However, there is also a great deal of content which is taught commonly from all viewpoints of information science. Information scientists, librarians, and computer specialists would gain by a knowledge of the problems of educating in the other fields, and by the knowledge of the materials and curricula available in them.

It therefore seemed reasonable to assume that the time was ripe and the need manifest for a symposium on education for information science, that would have the following objectives:

1. To coordinate curriculum and instruction in information science from the various orientations of library schools, information science programs, computer science programs, and other disciplines which use information science.
2. To establish communication between educators who would otherwise not have the opportunity to exchange ideas, problems and information.
3. To clarify the need for a cooperative curriculum development project in information science and to provide preliminary input from the field.

The plans for the symposium were approved by the ISAD and LED Boards of Directors and ASIS Executive Council, and on November 11-13, the symposium was held, substantially in the form in which it had been envisioned by the Planning Committee.

This document consists of the texts of the Papers prepared by the Invited Speakers. In an effort to make these contributions available as quickly as possible, we have kept the editing to a minimum, and have ommitted transcriptions of the discussion following the presentation of these papers.

No account of this symposium would be complete, accurate, or just without recording our gratitude to the remarkable people who contributed to its development and outcome. Our most obvious and public debt is to the authors of the papers, whose care in preparing thoughtful and sophisticated discussions represents the most substantial sort of compliment to the participants and organizers of the symposium. The very difficult task of developing the original proposal into a concrete set of working specifications was handled by the Planning Committee, whose members were:

James Liesener, University of Maryland (ALA, AALS)
Barbara Markuson (ALA, AALS)
Susan Martin, chairman, Harvard University (ALA, ASIS)
Ann Painter, Drexel University (ALA, ASIS, AALS)
Tefko Saracevic, Case Western Reserve University (ASIS, AALS)
Don S. Culbertson, ALA staff
Herbert R. Koller, ASIS staff

But their efforts would have counted for little without the support of the Boards of Directors of the ISAD and LED divisions of ALA, and the Executive Council of ASIS, who committed the resources and reputation of their organizations to the project at a stage in the planning when many details had to be accepted on faith.

Most of the administrative and procedural details were handled by Don S. Culbertson and Robert McAfee, Jr. in the executive offices of ALA and ASIS respectively. The arrangements for setting the Symposium up in Denver were excellently handled by Jack McCormack, and J. I. Smith, Associate Director of the ERIC Clearing House for Library and Information Sciences, assisted in the preparation of the Proceedings with great tact and skill.

But the person who provided the drive, excitement and vision that was the really indispensable contribution to bringing the idea for this symposium into being was Susan K. Martin, and it is above all to her leadership that all of us who participated in the project gratefully owe our involvement.

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STATE-OF-THE-ART: DEFINITION AND OVERVIEW OF INFORMATION SCIENCE EDUCATION

Louis Vagianos

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Dalhousie University
Halifax, Nova Scotia

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BUTTON, BUTTON WHO'S GOT THE BUTTON?

Louis Vagianos

WE'VE GOT THIS LITTLE PROBLEM

"In 1593, it was rumoured that a seven year old Silesian child, shedding its milk teeth, had grown a gold tooth in place of a molar. Horstius, then Professor of Medicine at the University of Helmstedt, wrote an account of the story and asserted that its causes were partly natural and partly miraculous, and that God had made the child a gift of the golden tooth to console Christendom, so mightily oppressed by the Turks at that time.

"In the same year, lest the tooth lack sufficient historical commentators, Rullandus wrote a further account of it. Two years later, Ingolsteterus, another scholar, published a refutation of Rullandus's theory and Rullandus's elegant and learned reply was not long coming. Another scholar, Libavius by name, collated all that had been written on the subject and added his own conclusions. Everyone of these remarkable works would have been quite perfect in itself, if only the tooth had been gold. Yet, when a goldsmith was finally consulted, it was discovered that the tooth had been skillfully covered with gold leaf. But then, all the learned tomes were written first, and the goldsmith consulted as an afterthought."[1]

Nothing is easier than to adopt this method in every field. Our ignorance is never so clearly shown up by our inability to

explain existing facts, as it is by specious explanation of imaginary phenomena. In short, we not only lack principles for arriving at truth, but we hold to others that enable us to commit errors.[2]

Clearly, this should not be the case with scientists, for their raison d'etre has been built on a mighty foundation, a foundation for all ages, forged in the firmament of time, continually evolving, and invulnerable; a foundation distinguished by one common denominator, dedicated to the understanding of the physical universe through systematic investigation and careful measurement, through the harnessing of curiosity, specialized training, rigid discipline, exceptional instruments, and perhaps through intuition and luck!

Yet scientific errors (which we are assured, by the way, may be fruitful if they are committed by great minds) are all too common. They bear the individual stamp of their perpetrators, and, collectively, some have given rise to entire schools of false thought and misspent activity. Such large scale delusions merit our attention, if only because they illustrate the power of preconceived ideas: the moment authority claims to have observed either an existent or non-existent phenomenon, many others, though neither dupes nor deliberate swindlers, are likely to declare that they, too, have seen the same thing. One reason may lie with the realization that science, any science, is like a haystack in which one man grubs desparately for a needle while others lie at the top of the rick, waiting, talking, writing,

or sleeping their lives away.

I believe that information science may now be busily engaged in developing and prepetuating such a large scale delusion within the fields of communication and information. Why do I believe it: For two reasons:

1) Information scientists have not understood the nature of their problem.

2) Information scientists lack the meaningful direction of realistic goals.

Quite predictably, we have created a situation akin to the example of the "gold tooth". For declarations of discovery abound and each is greeted by vigorous verbal supporters who expound without exploring.

Let us start by examining my first criticism: Information scientists have not understood the nature of their problem.

For several decades now it has become fashionable to discuss the information explosion as a significant social phenomenon. More recently, the concept has been enlarged to include the "communications revolution" and the concept of "future shock." So important, we are constantly being told, is information to decision making, and so inseparable is it from the process of research and development in scientific study, that insuring its appropriate transfer within social relationships in all institutions has become one of the single most important

tasks of civilized man. In fact some, many in this room, consider it at the level of a "foodstuff." As a result, during the last decade entirely new service industries based on significant new technologies have developed and enormous investments in time and money have been expended in discussing and analyzing the nature and possible ramifications brought on by these "revolutions" while progress towards new systems and solutions remains marginal.

AGAIN WHY?

One answer might be librarians. Many information scientists believe the librarians are responsible - that their conservative, unimaginative natures and their possionate resistance to change have forced them to accept an evolutionary rather then revolutionary process for development.

Such an answer may possess some truth and it would be convenient to pass along the blame to another group, but there is a more accurate reply: information scientists are failing because they have not asked the proper questions, and they are now trying frantically to solve the wrong problem.

Again, the obvious question, why? Let me begin the discussion with several self-evident, general observations.

Life on this planet is getting very complicated, very frustrating and difficult to cope with. The blame is always laid at the feet of technology, the villian which has spawned "the

children of Frankenstein." Information, like it or not, is one of these children. It expands ad infinitum and technological innovation gallops by leaps and bounds, but man's inner nature is, and remains, basically evolutionary not revolutionary. The dictionary's definition of evolution is that of gradual, progressive, peaceful change. A revolution is defined as a sudden, radical, complete change. The difference is principally in the rate of the speed of change. If you would compress any long-term evolution of any phase of our civilization into a short period of time, the end result would appear revolutionary to the original observer. More important: THE OUT COME OF EITHER PROCESS IS SELDOM PREDICTABLE AT THE BEGINNING.

This is particularly true of evolution as it involves man. For example, there appears to be nothing foreordained about the emergence of man, nor any trend demanding man's constant reappearance. I am assured there can no more be a random duplication of man than there is a random duplication of such complex genetic phenomena as fingerprints. <u>The situation is not one that is comparable to a series of identical casts of dice, but rather an endless addition of new genes building on what has previously been incorporated into a living creature through long ages.</u> Nature may gamble, but she gambles with constantly new and alternating dice.[3]

The proper utilization of information creates a comparable situation; It is both commonplace and fashionable to argue that

the selection, organization, analysis, and transmission of information is a prime requisite and an inseparable part of research and development, requiring every user to stand on the shoulders of the giants who went before him; but no one has provided conclusive evidence which delineates how much information,what kind, in what format and of what quality is needed. The reason is simple. The translation from data to knowledge,and to wisdom, has about it the same random quality of unpredictability as the process of evolution described earlier, because it depends on the differences represented by each user and a number of complex factors, almost all of which are related to the human brain, an organ we, even now, know very little about.

The human brain remains one of the last of the unknown frontiers. Its birth was relatively recent and was, we are told, an eruption that had about it the utter unpredictability of Nature when she chooses to bypass her accepted laws and to hurtle headlong into some unguessed experiment, appearing from the outset, whole but imperfect. To this experiment man owes his progress and because of it he has mortgaged his future. For he is now able to remain comparatively unchanged in structure while all around him other animals are subjected to the old laws of specialized selection. His brain evolves parts and replaces them, but only upon his mechanical inventions.[4]

HE is WE, and among the mechanical inventions, the parts we have evolved are the disciplines and institutions of our civilization. Parts make wholes only when accurate direction and

tangible goals have been provided. Yet man has not been an anticipatory creature. His past never demanded it and the world he inherited, until recently, did not require it. He seldom planned for orderly, long-range development and rarely measured the subsequent consequences of his inventions. The results have often been damaging and occasionally disastrous. Man has not yet learned the simple wisdom reflected in the old saying - when you don't know where a road leads, it sure as hell will take you there.

This brings me to the second criticism: namely, knowing where we're going!

KNOWING WHERE WE'RE GOING.

"If the Prince of Wei were to ask you to take over the government, what would you put first on your agenda?"

"The one thing needed," replied the Master," is the definition of terms. If the terms are ill-defined, statements disagree with facts, if statements disagree with facts, then business is mismanaged; when business is mismanaged, order and harmony do not flourish; when order and harmony do not flourish, then justice becomes arbitrary; and when justice becomes arbitrary, the people do not know how to move hand or foot."[5]

In June of this year, the Advisory Board of the National

Research Council of Canada (ABSTI) commissioned me to prepare a study to examine the forms of training, present and projected, for the broad spectrum of scientific and technical information work in Canada. The study has been completed and is in the final stages and will be presented to the Board in December.

The foundation for the report was to be the definition of an information specialist as drawn from surveying and reading the literature. As the literature was surveyed, a multiplicity of titles emerged. In the end, the term "information scientist," despite many differing definitions offered the broadest conceptual scope within the information fields, including:[6]

Abstractors

Documentalists

Documentation Specialists

Indexers

Information Managers

Information Officers

Information Scientists

Information Specialists

Information Technologists

Library Technicians

Literature Chemists

Science Librarians

Special Librarians

Subject Librarians

Technical Information Officers

Technical Literature Analysts

My search of the literature for relevant books and articles brought forward 4,000 citations. This excluded items in languages other than French and English. At this point, that is at the point of reading the material which I would not recommend to any of you, all hell broke loose.

A former philosophy professor of mine once advised me that education consists of finding facts to justify what you already believe, but to understand, and to make judgements, one must know what one is talking about. One must define, i.e. limit. Further, to produce a product - any product - one must be able to describe it. These are truisms whose implications, I hope, need no further explanation or proof to a group who created that memorable one-liner "garbage in, garbage out." The plain fact about information science, though, is that its practitioners do not know what they are taking about and are unable to describe the product they are trying to produce.

Anyone who has read extensively in the literature will recognize that the general state of information science is that of a house built on sand, an imposing structure of theory and hypothesis, lacking any clear and common definition. In fact, we have available several dozen complex intellectual statements explicating information science. Many of them disagree, alike

only in their lack of validity because of a failure to define the basic axioms of the field. It is not for nothing that most papers delivered at conferences or written about the subject "information science" begin with apologies for a lack of an operational definition, provide a personal definition, or demand that we leave "the slippery slopes of sterile semasiology" and get on to the work at hand. It may have been true for Humpy-Dumpty that when he used a word, he used it to mean what he wanted it to mean, neither more nor less; but he didn't work in the real world - he could avoid his creditors or his president.

This does not mean that constructing a definition is impossible. As was recently stated: "Information science, information technology ('informatics,' to quote a Dutch friend), is still an alchemy. It stands no better than chemistry stood before John Dalton's unifying concept of the atom. That his atoms are not our atoms is not yet of workaday significance - and it may never be! From his theory, chemistry was able - and still is able - to advance with confidence. We still await the Dalton of the information world. His place in history will be no less respected. Where is this sorely needed figure today? In the nursery, in a sixth form, in a postgraduate school - or facing me at this very moment?"[7] However, I do wish to observe that the task facing "our" Dalton is infinitely more formidable. Consider the object: He or she must find a formula which will reconcile information science as either a natural science, social science, information profession, or all three while recognizing

it has pure and applied research components. Moreover, our man or woman must provide a formula which will unify some, most, or all of the following disciplines into a working configuration, that is one which will improve the existing procedures and institution for selecting, organizing, analyzing, and transmitting information:

communication theory

information theory

cybernetics

semiotics:
- a) semantics
- b) pragmatics
- c) syntactics

mathematical logic

logical semantics

psychology
- a) engineering psychology
- b) psycho-linguistics
- c) labour psychology

book science/publishing

library science

bibliography

engineering (electrical)

linguistics

computer science

philosophy

education (learning theory)

biology (problem of mind)

physics (optics - photography)

graphics - printing

business administration

Wow! Ten years ago, I, as a neophyte library planner, was somewhat awed by the challenge accepted by a much respected medical consulting group who offered to plan Brown University's new medical complex. The complex was to include a medical library which, among other things, would take into account the impact of "multisensory media and nonverbal literature while providing for the new and very necessary medical library specialists, the medical communicationalist, possessing a sophisticated standard of technical knowledge, erudite, fluent in 3 or 4 languages, the physiologist and pharmacologist of human communications systems... the pathologist of the information overload."[8]

This, I now suggest, is small potatoes compared to the task facing educators in this room tonight. Is it any wonder, then, that there is a fundamental difficulty in establishing a generally accepted, basic, or even an applied curriculum in information science? No! The wonder is that so many of you who recognize this problem and have written about it in the literature are proceeding so vigorously, without it!

OUT OF THESE RUINS SHALL RISE?

According to the literature surveyed, information science, as a term, has one of three origins: V. Bush (forties), R. Hayes (late fifties), or Anonymous (early sixties). Its philosophic and intellectual underpinning, that is, its structural aspects, belong to the sixties.

What emerges from the literature are six distinct points of view each complete with high priest and disciples. Four are relevant to our discussion, though all will be mentioned:

First, those who see information science as a science (either natural or social) emerging as the result of an effort of interdisciplinary will. The resultant science would explain a variety of phenomena with theories derived from related sciences. It is research oriented with pure and applied science components. A pair of philosophic formulations quoted from the literature will suffice to characterize this group:

"Information science is that discipline that investigates the properties and behaviour of information, the forces governing the flow of information, and the means of processing information for optimum accessability and usability. It is concerned with the body of knowledge relating to the origination, collection, organization, storage, retrieval, interpretion, transmission, transformation, and utilization of information...It is an interdisciplinary science...It has both a pure science component which inquires into a subject without regard to its application, and an applied science component which develops services and products."[9]

"...Whatever label may be preferred, it denotes interest in aspects of production, manipulation, and application of signs and symobls...Signs and symbols are not spontaneous...must be derived...

require phenomena which is controllable, repeatable...(information science) is therefore a social science."[10]

A second grouping consists of those who see information science as a theoretical science explaining the basis of some existing discipline, one which stands in relation to that discipline as physics does to engineering. One example will suffice here:

"Information science comprises that set of research and development undertaking necessary to support the profession of librarianship."[11]

The third grouping consists of those who see information science as a meta-science of some existing disciplines, their potential unifying theory:

"...an emerging scientific discipline, the information sciences, still not fully defined, but resting on a base in logic, systems theory, psychology, and neuro-psychology."[12]

"The profession of information science deals with many aspects of information, its properties, origination, manipulation, structure, control, and use. The profession is concerned with information systems, their design, operation, evaluation, and components. It cuts across such disciplines as logic, behavioural sciences, cybernetics, communication theory, languages (both natural and synthetic), machine translation, and pure and applied mathematics. It interacts strongly with the development in the

new technologies of computers, automation, microimaging, storage and retrieval, and communication, transmission, and display of information."[13]

A fourth group consists of those who see information science as an information technology which produces a learned profession. This group would compare information science to a profession such as medicine and argue that a learned profession is not a science. The most important comparison in this analogy is the question of basic research. Medicine does very little of its own basic research. This sort of research is done by the sciences which support medicine (e.g. chemical therapy research). It concentrates on improving and developing application techniques and on training practitioners.[14]

The fifth and sixth groupings can be disposed of quickly. They have one thing in common - they are not involved. One group composed of fence sitters, indifferent or unable to assume a positive posture, stands aloof awaiting a winner; the other, including many librarians, professes wonderment at it all and sees no reason not to remain content with things as they are.

Natural science, interdisciplinary science, social science, meta-science, information technology, librarianship, what is your pleasure? Can you, as the man in the street is prone to say, merely pay your money and take your choice from the lot? I think not! Compare the qualifications put forward for information

science against those generally associated with the natural sciences.

The classical picture of a natural science is that of a body of knowledge, varified through experimentation and resting upon a corpus of generalizing hypotheses. The generalizing hypotheses which unify the phenomena of which the science is a subject, from the background of the science (e.g. ionic dissociation theory in chemistry, quantum theory in physics). These generalizing hypotheses elicit a wide measure of agreement among the scientists within the discipline; to challenge these hypotheses (as the indivisible atom of physics was challenged) is an event as profound as it is rare.

Once the structure of a science has been solidified, i.e. unified around a principle or several principles, it takes its place amid a family of disciplines. In time, problems emerge which lie between the boundaries of the established science. An attempt at unification is then made which often proves fruitful. The result is an interdisciplinary science (e.g. biochemistry, which deals with the chemical processing of living things, using concepts from both chemistry and biology). Training for such a role is straight-forward, since the new science has been created on stable building blocks, which have much in common.

There are many similarities upon which one could build a compelling argument for information science but <u>similar is not the same</u> and this is the danger. The natural sciences have such

validity, that despite the present climate of fiscal austerity and agitation against certain types of research, its practitioners continue to enjoy an extraordinary earning power and a prestige in the public mind second to none. The temptation to gain equivalent success has encouraged other, non-scientific disciplines to emulate the scientific approach and this has generated certain problems, not least among which is the development of a host of pseudo-sciences. Some of these groups are now learning that adoption of the name, manner, methods, and language of science will not guarantee the solving of intractable problems. The pernicious effect of this tendency may be ignored but in the long run cannot be overestimated. Some disciplines may be more complex than presently imagined or may be inexplicable in natural science terms. If the unifying synthesis of the scientific approach is impossible or ceases to be applicable, time tested and pragmatic routines will be corrupted by a series of half-truths and labels - simplified, stereotyped representations of ideas which have lost the originality and impact of the ideas they summarise. False claims and quack remedies become the order of the day.

TO CHOOSE, OH HOW TO CHOOSE, THAT IS THE QUESTION

Given the foregoing, it is not surprising to learn that any student wishing to select a university for education in information science would be confronted with a mystifying muddle. The assortment of programs is too wide and varied. He has to choose from:

Schools of Librarianship

Schools of Library Service

Schools of Library Science

Schools of Library and Information Science

Schools of Information Science
1) independent of library schools
2) related or affiliated with library schools

Departments of:
Computer Science
Communications Sciences
Engineering
Business Administration
Behavioural Sciences

Information science programs differ in their orientation. There are scattered undergraduate programs, a plethora of masters programs, and a handful of PhD programs. Three types of degree programs seem to be offered:

1) Those which are heavily weighted toward the theoretical aspects of information handling.

2) Those which are hardware and engineering-oriented and lean heavily on techniques for solving existing library problems.

3) Those which attempt to generalize the above so that the students, mostly librarians, will have an overview and might be better equipped to respond to work situations of the future.

Each program attempts some form of research with applied research by far the most significant component. Little effort has been made to integrate the needs of each of these areas into one information science curriculum. What is still more interesting, though, is that, with the exception of half a dozen schools, all others still award as their terminal degree a MA, MS, or PhD in Library

Science, Service, or Librarianship.

After even a cursory investigation of entrance requirements, the perspective student would quickly discover still more meaningless variety. In a recent survey[15] of universities which offer information science programs, 37 respondents indicated special requirements - 18 required a language, 7 programming, 9 mathematics, 2 linguistics. As is common in such studies, many indicated other special requirements which, as usual, they did not specify verbatim.

Reviewing information science curricula reveals still greater discrepancies. As indicated, courses may be oriented towards pure research or applied techniques and are often weighted in several directions: technological (engineering, mathematics), business administration (statistics, program budgeting), traditional (social sciences), etc. The course content lables are not helpful. Any among you who has tried to reconcile what a catalog describes as the course content and what is actually taught, realizes how significant the differences can be.

One is reminded of the caption which appears at the beginning of novels which might be misinterpreted, you know the one - "any similarity between..."
Few syllabi which can be assessed within the context of fully developed degree programs exist for consultation. In fairness, the problem of writing course descriptions for information science

is exacerbated by the lack of precise theoretical and operational definitions. (It is useful to note that course offerings range from no choice, i.e. one course, to as many as 25).

Assessing the instructional staff is equally frustrating. First, there is a shortage in the field. Second, the normal evaluative mechanisms used as yardsticks in other disciplines do not apply. For example, refereed journals, within the normal usage of the term in science, do not exist in librarianship and information science, PhD's have never been mandatory and more than 50% of those who have them have come from the disciplines of the humanities, social sciences, and librarianship.

Physical facilities and services are always a good indicator, but most students are not experienced enough to make such judgments. If they were able they would be astonished by the diversity of existing physical plants and the services provided within the differing programs.

Perusal of the advertisements in the job market would be more depressing. Until a clear idea is articluated of what an information scientist can do with the practical problems of the real world which is different from or superior to the existing library school products, no unusual demand, other than teaching or research, will be generated. This is particularly true in today's limited job market.

Finally, a student cannot expect advice or guidance from an external accrediting body. Most programs have not been evaluated and cannot be because, at present, no accrediting body exists which is competent to assess the quality of existing programs. More to the point, if it did, which standards would it apply?

ALL DRESSED UP AND NO PLACE TO GO

It is sad, then, to conclude that the state of education in information science is chaotic and confusing, because the problems which information science purports to address are real ones and the solutions are essential to civilized progress. Information science is man-made, our own invention, and we should no longer permit it to gallop in undisciplined fashion or to hide behind the excuses related to the growth pains which every emerging discipline undergoes. We can no longer proceed without generally accepted, concise, operational definitions, and tangible goals. Research personnel may not require such definitions and goals, but all educators and teachers know you cannot teach or train students without them. Any talk of curriculum development integrated courses or pooling of resources is nonsense without this first step. It is axiomatic that no discipline starts out whole, with a clear-cut theory or precise operational definitions, but surely we have been a long time "a borning." We could make a start by eliminating from our field "the terminological corruption which has gone well beyond what is inevitable into what is scandalous. Some...is deliberate

exploitation of vogue words for money and prestige...confused terminology confuses both aim and effort. Those may travel furthest who do not know where they are going, but they do not necessarily travel in the right direction."[16]

This is clearly an internal matter which we can control.

Deciding who we are is a horse of another color, yet it must be done. One caution - those who are willing to accept information science as a science, whether natural, social, or meta-science, and espouse its multi-disciplinary character are failing to grasp the enormity of the task. Simply put, the information scientist will be expected to duplicate the feat of the "Renaissance Man." He must be a generalist who can overmaster as many as 20 disciplines at a time of unprecedented change and during an age when it is generally acknowledged that it is impossible to master one discipline. No one school or one individual can hope to cope. If this is the route we decide to take, surely a federation of disciplines and personnel is the likely answer. Team and mission approaches are not new and have sometimes been conspicuously successful. It should be possible for schools to rationalize their resources by identifying existing strengths or accepting specialties which have been parcelled out among them in a non-duplicating, pre-determined manner. This is particularly true in Canada, a country with limited resources. There are precedents for such developments. Even in a country with the incredible financial resources of the United States, the sheer waste of effort and money generated by duplication should mitigate against such useless proliferation.

Developing a suitable methodology is always important and necessary. Where applicable, adopting and adapting the methods and rubrics of science will prove useful, but they constitute only a part, (one) of the tools that will be needed. At best, methodology is but a means, meaningless unless connected and inseparably attached to goals or ends. But which goals or ends?

At the risk of being presumptuous, there does seem one way out of the maze. It was suggested in the literature 7 years ago[14] and is an eminently sensible proposal, ideally explaining and resolving many of our problems. Let us adopt a position similar to the practioners of medicine as members of a learned society and not that of a group of scientists. Medicine is concerned with the diagnosis, treatment, and cure of disease. It applies, rather than creates basic research. It has generally recognized that such research, will occur in the scientific disciplines upon which it is based, and medicine itself will be concerned with the application, testing, and proving of advances in the preclinical and clinical sciences.

Information scientists, librarians, information technologists, etc., are concerned with the design, installation, and operation of information systems. Information science uses the developments of basic research to solve its existing problems (e.g. library automation, learning and information theory). It, too, is concerned with application, testing, and proving of existing advances for its service and training programs.

Both fields are plagued with lunatic fringes of quacks, flashing lights, faith healers. Both are confronted with cautious general practitioners who would avoid change. Both are service directed and both are changing rapidly. This seems to me a possible bridging of both worlds. Applied technology, team and mission grouping, and standard curricula could be more readily developed and would be the order of the day. We could still pick and choose what we need from perpheral disciplines, and we could still clothe ourselves in the wholecloth of a science, i.e. like medicines we would be accorded such public stature because, we would be using scientific approaches and we would be developing and applying the latest techniques and the most recent machines to solve new specialized problems.

We must not underestimate the pressures which will be placed upon us due to the changes in the economic climate. Many marginal disciplines and pseudo-sciences will be eleminated. Columbia University's recently announced termination of its linguistic department protends special omens for us as we have embraced it as a sister discipline. We have been smug enough for long enough. We must not put ourselves in the position of the atheist who, posthumously, discovered God and found himself all dressed up with no place to go.

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NEW CURRICULA IN INFORMATION SCIENCE

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I wish to divide this contribution into four distinct parts which together, will I think, explain my own position. The parts are: The input - that is to say the people who are going to become Information Scientists of the future; The traditional curriculum and its context; The Library of the future; and the Curriculum of the future.

The Input

Information Science is now an OK word. As recently as five years ago, the word was either not used or if used was not generally understood. The term then used to describe an Information Scientist was the traditional one: Librarian. An inspection of the advertisements for Technical Librarians during the last decade, would reveal that, whilst they were expected to have specialist competence in the subject literature of some scientific or technological field, they required little competence in anything other than the traditional bases of Librarianship which we shall discuss later. For this reason, the information specialist in a research Institute might be useful to the participating scientists in the sense of doing leg work, but exerted no really fundamental effect on the information purveyal process, and no effect whatever on the research process itself. Certainly no information specialist in a research institute would have been expected to predict the future directions of profitable research and development. These traditionally trained Librarians are, of

course, one of the inputs to a training program for information scientists.

The second of the inputs, which is of importance in this field, is the engineer. Engineers are,by nature and training, inquiring and innovative people. They are needful in information science, both for their contribution to the theory of communication and, more generally, for their research competence and developmental ability in improving information systems.

The third class of input is the Mathematician and Physical Scientist. In many cases people from this category drift into Information Science because of lack of job opportunities in their own specialities. Nevertheless they often become involved and interested, and form a valuable component of the system, particularly on account of their mathematical abilities.

Finally, and perhaps frivolously, one might say that there is an input from the ranks of unfrocked priests. It is an astonishing thing that in over a quarter of a century of academic life, I have never encountered people of this class in courses devoted to the sciences or to engineering. In Information Science, however, at the present count I have had five students of this class in the last five years!

The Traditional Curriculum

Before I can speak sensibly about an education program for the future of information science, I must say something of the present program and its defects. In effect, in even the more progressive schools of Library and Information Science, the core curriculum has

tended to be almost exclusively that of the Librarian. As a non-librarian it might be offensive of me to state what this is. From observation, however, I may say that at least part of the pre-requisites consist of (1) courses on the organization of the traditional library, (2) a course in cataloguing, and (3) a considerable study of some specialist literature, often humourously referred to as "the children's book".

Now, whilst there is presumably no objection to teaching any of these subjects to a professional librarian who is going to work in a small town library, such a curriculum is completely inadequate to give a perception on the part of the Librarian in a larger library of the problems of the future. What is much worse is that such a curriculum 'turns off', to use the modern idiom, people of the middle categories in the last section, that is to say engineers, mathematicians and physical scientists. These people are not prepared to waste their time on what they rightly regard as trivia. It is this traditional core instruction, foisted on the potential information scientist which has to be changed, and to which I will now turn my attention.

The Library of the Future

Before coming to the climax of the talk, it is well to spend a few minutes in discussing the form and function of the library of the future.

First as to form. For reasons of human inertia it is likely that conventional books will be with us for a long time, thus, in considering the library of the future, we have to consider the storage and manipulation of this traditional information source. In

addition to the book, however, there are new media such as microfilm, microfische, magnetic and video tape, and large scale computer storage. These will certainly form a part of the science library and, of course, of the central libraries of States and Organizations in the future.

I have mentioned the computer. This has current importance for ordering the operations of the library and performing such drudge tasks as cataloguing, and circulation control. The computer will also form an integral part of any information retrieval process.

One of the areas in which I have worked in the field of information science has been concerned with the geometric design of libraries to optimize them with respect to the information retrieval process. In this optimization, the computer forms a vital part and should enable the search process to be conducted more expeditiously and far more efficiently than it is at the present time.

Whilst I could identify many other areas of library interest and development, these will do as being indicative of the curriculum which they generate. One functional aspect of librarianship must however, be mentioned. It has been touched upon in the first section of this talk: the Librarian as a predictor of future development trends and profitable areas of research and development. It may be thought that this is stretching the duty of the Information Scientist too far. However, recent work by Dean William Goffman of Case Western Reserve University has shown that a study of the present state of development of the literature in a given subject can give an indication as to whether that subject is in a state of what he calls epidemic development, whether it is quiescent, or whether it is past its peak, and is relapsing into a state of classicism. The techniques which Goffman has developed are mathematical ones. They have, however, been proved capable of identifying areas of current interest, and of pre-

dicting new areas of interest considerably in advance of the point in time when the sheer volume of production makes identification obvious.

The New Curriculum

The foregoing remarks will have made it obvious that the new curriculum will differ considerably from that of the traditional one which I have already mentioned. Furthermore it will have prepared you for the fact that mathematics will loom large in the information science curriculum in the future. What particular aspect of mathematics should form this curriculum is of course, open to question, but from some experience of the field it would appear that the following branches and the extensions are of central importance.

1. Basic Algebra and Trigonometry, including set and group theory. If the inclusion of Trigonometry is puzzling, I remark that this is needed when investigations of relatedness are considered as distance measures in hyperspace.

2. Differential and integral calculus, with some calculus of variations, leading to the study of differential and integral equations. The calculus is of course, the central tool in the solution of time varying problems. Variation calculus is concerned with optimization of functions as indeed, on a more elementary plane, is the differential calculus. It will thus be evident that these subjects have an immediate relationship to the optimization of information systems.

3. Boolean Algebra and symbolic logic. Two subjects whose importance is again fairly obvious, in that they are at the centre of coding for information retrieval.

4. Probability and statistics. At the elementary level obviously for record analysis. In a more advanced context for frequency structured

relationships and predictive analysis.

5. The structure of computing systems and their programming. In this modern age nothing more need be said on this topic.

6. Creative design. Probably only for the specialist, and possibly only as a post-graduate option. However, creative design will appeal to the engineer and have direct applications in the implementation of information systems in the immediate future.

I am sorry that, having expressed these opinions, I am not with you to debate them. I am sure, however, that Frank Dolan, who has kindly agreed to read this paper, will defend at least some of the positions that I have taken, and I hope that some of my friends from the School of Library and Information Science at Case Western University may also be there to insert their criticisms and hopefully, in at least some cases, their approval of what I am proposing.

THEORETICAL LIBRARIANSHIP AND INFORMATION SCIENCE

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ABSTRACT: Theoretical librarianship is the study of the problem of access - access to data and access to documents. We now seem to be at an impasse in our work on the theory of access systems (i.e., question-answering systems and literature searching systems). If we are to move ahead in our theorizing about information retrieval systems, then we must enlarge our conception of what the problem of information access is about. This involves an analysis of information and its properties by reference to its relation with knowing systems. This paper argues that information science is the study of knowing systems and that theoretical librarianship must move in the direction of information science if it is to progress. It follows, therefore, that education in librarianship needs to be restructured.

1. INTRODUCTION

What should be the emphasis and orientation of an information science program within a school of librarianship? What is the relationship between librarianship and information science, and what implications for education flow from a consideration of this relationship? These are the issues that I propose to examine with you this morning.

However, please notice at the very outset that this will not be a description of our program at Berkeley. I will not talk about the School of Librarianship at Berkeley because we don't have a well developed information science program; certainly not one that is guided and justified in terms of the full meaning of information science and the future of librarianship. We, as a faculty of the school, are still in the process of attempting to clarify and unify our thinking about the aims of advanced education in library science and the best ways of achieving those ends. This process of clarification and unification is tough for many reasons. It involves unfolding what information science is about, and also questions about future directions for research and development in librarianship. And, in addition, it always involves questions about the role of librarianship in our society.

For over two decades, ever since the development of the computer, there has been enthusiastic talk about the new science of information science, and about how librarianship relates to it. How do we see this relationship today? In my view the key theoretical problem of librarianship is the problem of access to stored information. And, one of the central problems of information science is that of information search and retrieval. If these problems concerning identification and access to information are central to both disciplines, in what sense, if any, are they separate disciplines? I see theoretical librarianship as a part of information science whose subject is the process for knowing. And, in my view, education in theoretical librarianship must begin to be concerned more directly with those information processes that underlie the activity of knowing.

2. LIBRARIANSHIP: SOME FIRST DISTINCTIONS

I want to lead us from librarianship toward the foundations of information science. Let me start by making a few initial distinctions that may help to clear the way. Along one dimension, I want to distinguish between problems of control and problems of access in library systems. Along an orthogonal dimension, I want to distinguish between the applied (or practical) and the theoretical aspects of these problems. There are, it seems to me, two quite different kinds of information processing in libraries. The first is information processing for the purpose of control; the second is information processing for the purpose of access. The control problems deal with keeping track of the system; e.g., monitoring what has been ordered, received, paid for; what has been indexed, shelved, borrowed, lost, rebound, etc. In many of today's libraries, steps are being taken to automate some of these control functions. We can, of course, distinguish between two aspects of work on control (whether for automated systems or not); there are the practical

questions of "how to" handle control functions, and there are the theoretical questions concerning optimal rules (and models) for handling control functions in a library system.

The second kind of information processing in library systems concerns the central problem of access. The problem of access is the problem of how to analyze and identify stored information and requests for information, in order to retrieve all and only that which is wanted. Access systems can be mechanized or not. Among the class of mechanized systems it has become more or less standard to distinguish between two different kinds of retrieval systems. These are: question-answering systems which are designed to handle access to data, and literature-searching systems which are designed to handle access to documents. There are, of course, both practical and theoretical aspects to the problems of access, but in the main I want to emphasize the theoretical aspects of the problem of access.

3. INTELLECTUAL ACCESS: A CLOSER LOOK

The problem of question-answering systems is the problem of how to design a mechanical system that will store large amounts of information in order to be able to answer arbitrary questions related to that stored information. This means that if the answer to a question (such as: "When was Isaac Newton born?") is not stored explicitly, the system can deduce the proper answer from its stored data, just as you and I can deduce Newton's birthdate from a knowledge that he was 84 when he died in 1727. Two key theoretical problem areas in the design of question-answering systems are: (1) development of rules for analyzing data and requests that are expressed in ordinary (natural) language; and (2) development of rules of analysis and deduction so that a machine can make logically explicit (for retrieval) information that is only implicitly contained in its stored data. The problem of how to analyze ordinary language (on the basis of its content), and the question of the relationship between ordinary language and formal logic, are, of course, intimately related. In fact, one of the "standard" ways of organizing a question-answering system has been first to map ordinary language sentences into their equivalents in a formal language, store the information in the form of basic sentences of logic and then, where possible, use existing rules of deduction to derive desired consequences. We don't have the foggiest idea how human beings are able to comprehend ordinary language in order to analyze information, make deductions, find conclusions, and in general, answer questions. And, our present approach to designing question-answering systems via the heavy use of formal logic allows us to handle only relatively simple kinds of information. But beyond that we seem to be an impasse.

The theoretical problem of literature searching is the problem of how to design a mechanical system such that given a topic request and a large collection of stored documents, the machine can predict which of its stored documents, if read by the inquiring patron, will most probably satisfy his information need. The approach to this problem in the past has been via indexing. That is, documents are identified

by assigning index terms to each, and every topic request for information must be expressed as one, or a logical combination of, index terms. A computer can then be used to implement one of a variety of rules for calculating the "closeness" between the indexes of a document and those that constitute the request. The implicit assumption underlying the design of such systems is that those documents whose index tags most closely match those of the request will most probably satisfy the requesting patron.

As you must know, many different techniques have been tested for assigning index tags to documents, formulating requests, and for matching document indexes with requests. The various search systems based on these techniques have functioned with varying degrees of success. (It would be much more correct to say that we can't even say precisely how effectively any literature searching system does, in fact, operate, because we have no single well established measure of retrieval effectiveness.) Perhaps, as in the case of question-answering systems, it would be too strong to say that we have reached an impasse, but surely it does seem that we have reached some sort of a plateau in our work in this field. Thus, the main question that I want to raise with you this morning is the following one: What might be needed if we are to move off of this plateau and up on to a next higher level of knowledge concerning the problem of access systems?

4. THEORETICAL DIRECTIONS: SOME SPECULATIONS

My personal opinion is that in the design of models for question-answering systems, we have stuck too closely to the use of logical languages, and in the design of models for literature-searching systems, we have dealt too exclusively with the problem of how to assign and process index tags. I feel that if we are to move ahead in our theorizing about the design of information retrieval systems, then we must enlarge our conception of what the problem of information access is about. Let me elaborate briefly in the case of literature search systems. The problem, again, is for a machine to analyze a document and a topic request, and to predict whether or not (or to what degree) that document, when read by the requesting patron, will satisfy his information need. This formulation of the problem implies, in some sense, that the machine in question must have rules on the basis of which it can estimate the impact of a document on the mind of its receiver. That is, textual information when read by an intelligent receiver changes states of knowledge and belief. How can this process be predicted? If we are to use a machine to make any predictions, we need to provide it with rules, and this in turn presupposes that we have some ideas about the process of comprehension, i.e., the process by means of which information changes states of knowledge and belief. And this, in turn, presupposes that we have some kind of a model of mind and an understanding of the nature of understanding. No small undertaking!

Thus it seems to me that the theoretical directions we will have to take if we are to move ahead in the information retrieval field are in the directions aimed at an understanding of information processing in intelligent (knowing) systems. How do most humans analyze requests, search for and retrieve information? What kinds of information processing

go on internally when a person decides that he has found relevant information, or useful information; what happens internally when one says that his information need has been satisfied? And can we hope to formulate for artificial systems optimal information processing rules prescribing the operations of analysis, representation, organization, search and retrieval? To even pose the problem in this very broad way is to enlarge the scope of the information retrieval problem and thus to take it far beyond what we might ordinarily think of as the scope of a library school curriculum. Again, I am suggesting the following line of argument. The heart of the so-called library problem is the problem of intellectual access to stored information. An understanding of the problem of access, in turn, leads to questions concerning information processing in the nervous system, and to questions of optimal organization of an intelligent artifact. This leads to neuro-physiology, psychology, and epistemology, as well as logic, computing, and the theory of artificial intelligence. There is a single name that has been given to this range of topics that clusters around the question of information and theories of information processing. I refer to the name that Norbert Wiener gave to this field of study over 25 years ago. The name is "cybernetics," but perhaps "information science" is a better title. In any case, my line of argument suggests that the theoretical direction toward which a library science program ought to point is in the broad directions of cybernetics or information science. What does this mean and what are its implications for education?

5. TOWARD INFORMATION SCIENCE

I am not the first among us, nor will I be the last to attempt to sketch out the boundaries and the geography of that territory that goes by the name "information science."* But if I wish to argue that theoretical librarianship must move in that direction, then I must offer some kind of map, however rough, of that no-man's land called "information science."

First of all, I don't equate information science with computer science. Information science is not primarily about computers, programming, operating systems, switching theory, or automata theory. And it is not primarily about the design of communication systems, coding theory, theory of servo-mechanisms, etc. And it is certainly not about systems analysis.

What is information science about? What is its subject matter? A key concept, of course, is that of information, and information science is concerned with explicating the full meaning of information, describing the properties of information, and establishing ways of

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* In their Opinion Paper discussion of the scope and meaning of this subject, Otten and Debons use the new term "Informatology." See "Toward a Metascience of Information: Informatology." J.A.S.I.S., Vol. 21, No. 1, Jan-Feb., 1970, pp. 89-94.

measuring those properties. And information science is concerned with the formulation of theories on how to analyze, organize, relate, store, process, search for, and retrieve information. Information science is concerned fundamentally with the kinds and ways of information processing that correlate with the process of comprehending; i.e., information science, at its very core, is the scientific study of mechanisms for understanding. Perhaps this can be clarified briefly as follows:

Information, whether in books in libraries or in digital memories in on-line data retrieval systems, is that which changes what its reader knows or believes. When put this way, we see that information can only be explained and understood by reference to its relation with the knowing system ("mind") of its receiver. Furthermore, such key notions as the meaning of information, the relevance of information, the utility of information, must be explained in terms of the impact of the information in question on the knowing system of the receiver. How does information change what a person knows? Information about the world must be represented in some physical form. How is it represented in the human? Knowledge, whatever else we say about it, does have a physical representation in the brain of the knower (e.g., in the form of signals that ultimately generate intelligent, mind-like behavior.) What is the logical structure of physical knowledge? What is a state of knowledge? Can we talk of an information need as the difference between a desired state of knowledge, and some actual state of knowledge? And might it be possible to measure the relevance of information in terms of whether (or to what degree) it changes a given state of knowledge to some desired state? These remarks and questions are intended to amplify the notion that information science is the study of information, but that information, in turn, can only be understood in terms of how it affects knowing systems. Thus information science is the scientific study of knowing systems (natural or artificial); i.e., it is the study of the information processing that must underline such activities as knowing, understanding, comprehending, believing, thinking, solving, etc. (And, of course, all of this was implicit in the writing of Norbert Wiener when he first explained the meaning of cybernetics.)

6. IMPLICATIONS FOR EDUCATION

My interpretation of information science makes it a subject whose subject matter is the activity of knowing, and how knowing can be explained in terms of underlying information processing. And, I believe that theoretical librarianship must move in the direction of information science if it is to progress. Therefore, if my view on these matters is even close to being correct, it follows that education in librarianship does need restructuring. The question is: what kind of restructuring? Unfortunately, I cannot spell out at this time a detailed list of those courses and their sequencing that would constitute a full program in theoretical librarianship. One reason is simply that some of the most important courses do not yet exist. However, this fact need not deter us. Our concern is with education and the preparation of those advanced students who will do new work in this field. We have to point the way. Thus, although I cannot propose at this time a complete curriculum in theoretical librarianship, I do urge those of you who share my view to

help widen the scope of theoretical librarianship along the lines I have already suggested. And, most importantly, point your students in the direction of information science.

Information Science Education

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We can categorize the possible objectives of information science education into three general types. The first, and most prevalent, is 'professional' training intended to equip people to operate existing communication institutions. Given the sponsorship of the present symposium I will use libraries as examples throughout, although I think the argument generalizes to other communication institutions also. The second objective is to train information technologists who will be the inventors or 'engineers' expected to develop and test new information systems. My definition of a technologist is a broad one that includes behavioral and policy considerations. The third objective is to train scientists whose goal is a deeper understanding of information processes in general.

Professional Training

Technology Utilization

We can subdivide professional training into three general aspects, although one aspect dominates and the other two tend to be neglected. The dominant aspect of professional training for which information science is relevant is the utilization of technology. That may seem surprising to a librarian who works with books and card catalogs and typewriters or to a

newspaper reporter who works with a pencil and paper, telephones and a typewriter. But the technology of writing and printing is as much a technology of information processing as photography (micro or otherwise), electronic transmission, or computer processing. Librarians share with journalists, photographers, film-makers, broadcasters and computer programmers the need to be able to effectively operate or manipulate their chosen technology or medium of communication.

Management Training

The second necessary aspect of professional information science training is management or organizational skill training. Communication institutions, whether newspapers, libraries, broadcasting companies or telephone companies, share with other institutions the need for people who can operate effectively within the existing institutional framework. Although the skills needed are in large measure communication and information processing skills, this need is not restricted to communication institutions. Graduate schools of business devote more explicit attention to training in the organizational and management skills needed to operate any institution.

Use of Feedback

The third and most neglected aspect of professional information science training concerns the relationship of the communication institution to the rest of society. In the case of business institutions, this task is much simpler than for libraries. Businesses have a well defined medium of communication for relating to the rest of the society -- money. Money provides the differentiated feedback to tell the institution which of its products and services are appreciated and the profitability test provides

an accepted measure of success. Market research is one way of obtaining information from the potential clients of the institution that can help it perform more effectively. Public institutions such as libraries find it much more difficult to determine user needs and interests, to evaluate the effectiveness of their operations, and to provide the systematic information feedback that allows them to be rapidly responsive to changes in needs and interests of their clients. Since the financial resources of libraries come from different sources than those served (or come indirectly) there is the additional problem of obtaining resources to operate. Sometimes successful service can be self-defeating in that it generates further demands for service that cannot be met because of budget constraints. These problems are crucial to the long-run survival of public information institutions. They deserve more attention in professional training.

Training Tomorrow's Professionals for Yesterday's Institutions

This characterization of professional training as training to operate existing communication institutions, although useful for some purposes, is a dangerous oversimplification. If the communication media and institutions were likely to remain stable throughout the careers of those being professionally trained there would be few problems. But during a time of rapid technological change in communication media that will certainly leave its mark in the form of changes in communications institutions, there is a danger that tomorrow's professionals may be trained for yesterday's institutions. The institutions themselves, whether libraries or newspapers or whatever, are likely to demand personnel trained to handle the immediate short-run problems. The questions that education institutions must answer is whether they also wish to take the short-run view, or whether they have a larger responsibility to consider the long-run

problems. It is a matter of whether the education institutions choose to lead or to follow the professional institutions they serve. If they are to lead, then it is imperative that professional training also include elements of our two remaining categories of information science education -- technology development and scientific understanding.

Technology Development

Change Technology or Change Function?

Communication technology is undergoing considerable change and is likely to continue to do so for at least the next 20 years. There will be major changes in information storage technology (e.g., ultrafiche, trillion bit laser memories, holographic memories, etc.), in transmission technology (e.g., cable television, communication satellites, laser transmission, etc.) and in access and processing technology (primarily computer systems). As new technological potentials are developed, made more economical or more widely diffused through the society, then shifts in usage patterns are bound to develop and institutions that have grown up around earlier technologies will be forced to adapt. Existing institutions will be forced to change technologies (if they are to continue to perform the same functions effectively) or to change function (if they insist on keeping the same technology).

I am a strong supporter of libraries in their functional role of providing all people with easy access to information and education about whatever they want whenever they want. The library has long been a cornerstone in our democratic system of government, which requires an informed

electorate to operate effectively. This historic role of being the receiver's agent in a communication system that has in the past been largely dominated by the senders of messages, is becoming increasingly important as the society itself becomes more complex and as individual citizens become more involved in the decision-making processes of the society. Therefore, I am a strong advocate of libraries developing and adopting whatever technologies can best help them to serve that function. The alternative would be for libraries to maintain only their traditional technologies and permit new institutions to grow up around the new technologies, possibly usurping the library's traditional function. The implication for educational institutions is clear: Train people who can develop and adapt new technology and new techniques to make it easier to provide the kind of information access capability our society requires.

New Technologies

There are two dominate technologies involved in current and future changes in information access capability. One is computer technology and the other is a cluster of video technologies, including videotape, video cassettes, cable television, photocopying devices, microfiche, etc. It should not be necessary for the information technologist to become a hardware engineer capable of developing new physical devices, although he should be able to understand the hardware well enough to utilize it effectively. He should also be able to write specifications for needed hardware in a form understandable by the appropriate hardware people. One example of this would be specification of characteristics necessary in a computer display terminal for bibliographic data in a library application.

Another would be specification of performance characteristics needed in a random access microfiche system. He should also be familiar with the major trends in technology to be able to judge which aspects are likely to remain stable and where the significant technical developments and cost reductions are likely to appear in the following five to ten years.

He should become a highly competent user of the technology so that he has a first-hand knowledge of both potentials and limitations and can select hardware knowledgeably. In the case of computer technology, he should become more than an applications programmer capable of writing programs in some standard programming language whether Basic, Cobol, Fortran or Assembler. He should become knowledgeable about the systems programming skills needed to implement a new programming language or system which non-programmer users can use effectively to perform their information selection and processing tasks.

Behavioral Research

The goal of developing effective new information systems requires two additional areas of knowledge besides the obviously technical skills required for development of a computer or video information system. A second area of knowledge concerns user needs and user behavior. Technology systems developed in isolation from the needs and information-seeking styles of specific audiences may work well in some technical sense, but are unlikely to be satisfactory for real users. One danger is that the system may be designed for an imagined rather than a real need. Another is that the 'human factors' are not adequately taken into account to make it easy for non-technical users to comfortably utilize the system. What needs

to be developed is not a technology system but a man-machine symbiosis that allows real users to access relevant information on real problems. Designing a system for the general public to use is a much more difficult task than designing one that will be operated by paid employees or other captive audiences. Solid training is therefore required in behavioral science research techniques as well as technology systems development techniques.

Social Institutions and Public Policy

The third component needed for effective technology development is detailed understanding of existing communication institutions and public policies for communication. A potentially effective information system, even one that has adequately taken into account user needs and user characteristics, is likely to remain a laboratory curiosity if there is no reasonable strategy for existing institutions to make the transition from present to future technology or for new institutions to develop around the new technology. In the case of communication technology in this society, this requires an understanding of the regulatory process. The promise of electronic technology for remote access to library services may never be realized if Federal Communications Commission regulations and local cable television franchising practices do not take into account the possibility of libraries extending their information services directly to homes via the new communication technology. New technologies are never introduced into a social vacuum. The economic, political, and social consequences for existing institutions must be studied as carefully as the technology and the behavior of its users. The systems designer and developer who ignores the problem of transition strategies for social institutions, in this case libraries, has a certain recipe for failure.

All three of these components of effective information systems development -- technology, human behavior, and social institutions -- will require the acquisition of new knowledge as well as application of old knowledge. The problem is a mission-oriented one of accomplishing social goals, rather than a pure knowledge problem, but new knowledge is essential to satisfactorily accomplish the social goals of improved information service. Therefore, a strong component of information science, as a basic science, should be included in curricula planned for information technologists.

Basic Information Science

One reasonable goal for information science education, and one which can attain the greatest prestige within existing academic value systems, is that of training scientists. The goal can be expressed as deeper understanding, development of abstract principles, knowledge, truth, or some near synonym of these.

Fundamental Nature of Information

The nature of information and information processes may be the fundamental focus of science for the next century, just as science in the past two centuries has focussed on matter and energy. Information processes control the utilization of matter and energy. The fundamental relationship between information and energy has been suspected for at least the past 20 years since Claude Shannon's creation of the mathematical theory of information turned out to have equations identical to the entropy equations of the second law of thermodynamics. More recent developments in the

understanding of the relationship between information and energy are discussed in the September, 1971 issue of Scientific American (Myron Tribus and Edward McIrvine, "Engergy and Information", Scientific American, 1971, vol. 224, number 3, pages 179-188).

The recent major advances in the biological sciences since Watson and Crick's discovery of the 'genetic code' can be largely attributed to the deeper understanding of how biological information is stored and transmitted from one generation to the next.

Although the analogies have yet to be formalized into an abstract theory of information, there are interesting similarities between machine information processing in computer systems, cognitive information processing in humans (biological systems), and human communication in social systems. All three aspects are involved in the development of information systems. Better understanding of the fundamental processes would be certain to lead to improved system design.

Toward a General Theory of Information

What is presently known as the mathematical theory of information, powerful though it is, is a very special case compared to what is needed in a general theory of information. Present theory is essentially a theory of efficient coding that measures the capacity of information channels and the efficiency of transmission in 'bits' (binary digits) of information under an assumption that there is a known set of possible messages that is perfectly shared between sender and receiver. In other words, the structure or context of the 'information' (as defined by a shared set of possible messages) must be identical at both ends of the information channel. This obviously does not apply to libraries or most human communication because

the context of the message is different at the sending and receiving end. What is needed is a theory of information permitting rigorous formalization and measurement of changes in information structure, not just quantity of transmission within a given structure. If we can find a way to formalize the context or boundaries involved in processing an item of information (whether by man or machine) we might then be able to determine the extent to which information processing results in changes in the structure. (If we are thinking of a human being as an information processer we can think of this as changes in his cognitive map of his environment.) Given such a formalization we could measure similarities and differences in information structure between senders and receivers involved in a particular communication and determine whether their structures are moving closer together or farther apart.

Interdisciplinary Effort

The problems of information are so fundamental and cut across so many present disciplinary boundaries that it is nearly impossible to find an academic department within existing university structures in which to pursue a fundamental theory of information without being constrained by the assumptions of a particular discipline or profession. Cybernetics and general system theory come closest to the scope required but these are seldom found within a single department. A strong foundation in mathematics would be essential; there is some basis to suspect that the subfield of mathematics known as graph theory may provide a basis for formalizing information structures. Present information theory is the province of departments of electrical engineering. People wishing to explore the clues

in the relationship between information and energy will need a good grounding in physics. The fields of computer science, psychology, sociology and linguistics may provide necessary clues that permit a general theory of information to emerge. One can speculate that the present boundaries of academic disciplines and departments present a major impediment to the development of the needed basic theory of information. On the other hand, we will not know the appropriate way to draw academic boundaries until after the theory has been discovered; present intuitions may be quite on the wrong track. The closest analogy lies in the recent emergence of departments of molecular biology -- a trend which followed rather than preceded the discovery of the genetic code. One can argue that we need to have a theory to teach before we worry about finding an appropriate academic department to teach it in.

The crux of the present problem in education for a basic science of information is thus to provide a sufficiently flexible academic environment in which the holy grail of a general theory of information can be sought. An academic home needs to be provided for bright people who wish to study interdisciplinary programs involving such diverse topics as cognitive psychology, artificial intelligence, neurophysiology, molecular biology, and electrical circuit theory, all in the interests of developing a theory of information.

Stanford's Program

The information systems Ph.D. program which I direct in Stanford's Communication Department is focussed on technology development in the broad sense discussed earlier, including behavioral science, computer

science (and use of technology generally) and analysis of social institutions. Much of our financial support comes from a training grant from the National Library of Medicine and so we have a particular focus on biomedical communication. Nevertheless, we feel that we are likely to be of most use to the National Library of Medicine if we approach the problem of developing improved information systems at a level of generality that would make the results apply to law libraries, technical information centers, public libraries or hospital systems for medical patient records. This would not be the case, of course, if we were engaged in the professional training of medical librarians. But we have only Ph.D. and postdoctoral programs. We do not offer an 'information science' program at the M.A. level, nor do we engage in any professional training in this area.

We do not teach a basic science of information as such, because we do not think that science exists yet. We do teach basic science in other areas, including behavioral science, which are needed to focus on information system problems. And we try to maintain the flexibility in our Ph.D. programs to provide encouragement for particularly well qualified students to tackle the fundamental information science problem if they wish.

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CURRICULUM DEVELOPMENT

by

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INTRODUCTION

Curriculum development and the problems associated with it will be discussed primarily by describing three examples. The first example, which will be treated at some length, will be the development of CURRICULUM 68 by the Curriculum Committee on Computer Science (C^3S) of the Association for Computing Machinery (ACM). This curriculum has had a very great impact on computer science curricula throughout the United States and, in fact, throughout the world. The second example to be discussed will be computer science curriculum at the University of Maryland; and the third example will be the early stages in the development of the curriculum in information science at the George Institute of Technology.

The discussion of CURRICULUM 68 will bring out general curriculum development problems, whereas the discussion of the latter two examples will bring out some of the more specific problems associated with the local college scene.

CURRICULUM 68

CURRICULUM 68, a set of recommendations for academic programs in computer science, actually started development back as early as 1962. A small group of computer science personnel began meeting at odd times during national conferences, such as the Association for Computing Machinery meetings, the Fall Joint Computer Conferences, the Spring Joint Computer Conferences, and the annual College and University Machine Records Conferences.

Our concern was for educational programs related to computers. The first actual visable activity that resulted from these early meetings was a panel discussion held during ACM's 1963 National Conference in Denver. Six educators presented papers describing several courses which could form the basis for a computer science curriculum. The topics covered in that original panel were as follows:

1. Introducing Digital Computers (Bruce W. Arden)
2. Programming of Digital Computers (A. J. Perlis)
3. An Undergraduate Curriculum in Numerical Analysis (George E. Forsythe)
4. Logic for Computer Science (Robert Korfhage)
5. Mechanical Languages-A Course Specification (Saul Gorn)
6. The Place of Logical Design and Switching Theory in the Computer Curriculum (David E. Muller)

This panel discussion resulted in a set of articles which appeared in the April 1964 issue of the Communications of ACM, under the general heading of Computer Science Curriculum. [1] At that time these were the prime course areas being covered by programs in computer science. The participants in this panel and also the authors of the articles appearing in the Communications were carefully selected by the Curriculum Committee on Computer Science of ACM in order to represent what was felt to be some of the best efforts in those areas at that time. All of the people involved in this panel are still active and contributing to the computer science field.

By using the results of the above panel and the later publications as a stepping stone, the Curriculum Committee (which then consisted of eight people) proceeded to attack the problem of developing a broader based

curriculum. The Committee met frequently before, after or during national conferences to discuss an undergraduate degree program in computer science. Numerous consultants at these conferences were used in the development of the curriculum. A major effort was carried out during the summer of 1964 when our Committee was hosted for one week at the Homestead in Poughkeepsie, New York as guests of the International Business Machines Corporation. It was at this session that the major actual formal writing of course outlines was done. We had available two or three experts in each area for this writing session. When these course outlines were put together, drafts were forwarded to a number of computer scientists in the United States and Canada for suggestions. Modifications were made based on their suggestions. This work was ultimately further refined and published in the Communications of ACM in September 1965 under the title of "An Undergraduate Program in Computer Science -- Preliminary Recommendations". [2] These preliminary recommendatins contained outlines for the following sixteen courses:

REQUIRED:

1. Introduction to Algorithmic Processes
2. Computer Organization and Programming
3. Numerical Calculus
4. Information Structures
5. Algorithmic Languages and Compilers

ELECTIVE:

6. Logic Design and Switching Theory
7. Numerical Analysis I
8. Numerical Analysis II
9. Computer and Programming Systems
10. Combinatories and Graph Theory
11. Systems Simulations
12. Mathematical Optimization Techniques
13. Constructive Logic
14. Introduction to Automata Theory
15. Formal Languages
16. Heuristic Programming

During the final stages of the publication of our preliminary recommendations, negotiations were in progress with the National Science Foundation for support of our curriculum activities. Up to this point we had received no financial support from any outside organization other than being hosted for that one week by IBM. As a result of our NSF negotiations, we did obtain a Grant (NSF GY-305) in the amount of about $61,350.00. This Grant was an essential element in the further development of our curriculum activites. It enabled us to hold curriculum discussion meetings independent of national meetings and also enabled us to pay consultants to work with us at greater length. Actually a good number of our meetings were still held prior to National Conferences, which meant that in addition to formulating our ideas and getting them written down during our formal sessions, we had an opportunity to test them on our colleagues during the Conferences. This meant that formal and informal curriculum discussions went on usually for a period of over a week. These curriculum discussions were perhaps among the most heated discussions I have ever been involved in throughout my career. The Curriculum Committee was a dedicated group which felt that it was trying to devise a curriculum which would be valuable for a period of several years despite the fact that it was being done during a period of rapid change both in computer science courses and in computer technology. It was done during a period of time when very few textbooks were available. Consequently one of our primary aims was to motivate the writing of much needed textbooks in this area. In this connection a number of publishers did make considerable effort to keep up with the work of the Committee and attempted to track down any efforts in the textbook area that they could locate. I believe it is safe to report that to some extent these efforts were successful since a large number of texts are now available in this area, though much work remains to be done in the textbook category.

CURRICULUM 68 was published in the Communications of ACM in March, 1968.[3] This publication presented a relatively complete description of an undergraduate degree program in computer science. It included 22 separate courses. They were as follows:

BASIC:

B1. Introduction to Computing
B2. Computers and Programming
B3. Introduction to Discrete Structures
B4. Numerical Calculus

INTERMEDIATE:

I1. Data Structures
I2. Programming Languages
I3. Computer Organization
I4. Systems Programming
I5. Compiler Construction
I6. Switching Theory
I7. Sequential Machines
I8. Numerical Analysis I
I9. Numerical Analysis II

ADVANCED:

A1. Formal Languages and Syntactic
A2. Advanced Computer Organization
A3. Analog and Hybrid Computing
A4. System Simulation
A5. Information Organization and Retrieval
A6. Computer Graphics
A7. Theory of Computability
A8. Large-scale Information Processing Systems
A9. Artificial Intelligence and Heuristic Programming

This curriculum has been and still is being widely used as the basis for the development of undergraduate degree programs in computer science. It was never the intent of the Curriculum Committee that it be used precisely as written. It was the hope of the Committee that the base laid down in the report would be sufficiently broad that many schools of different types would be able to pick from this and develop their own undergraduate curriculum. Just recently in a conversation with the Head of a Computer Science Department, he remarked that they were still using CURRICULUM 68 outlines in

some of their courses but that they were unable to cover all that was suggested in the outlines. From my point of view, this is precisely as it should be. We realized at the time that our outlines were relatively broad and included more material than is covered in a usual three hour semester course.

One problem or aspect of curriculum development that I am sure this group would be particularly interested in is the problem of classification. The Curriculum Committee spent many hours attempting to define and classify the subject areas of computer science. This has been and still is a major problem for our subject or for any subject as a matter of fact. In the discussion of our undergraduate degree program, despite many arguments against it, we finally classified the subject into three major divisions:

INFORMATION STRUCTURES AND PROCESSES

INFORMATION PROCESSING SYSTEMS

METHODOLOGIES

In the Information Structures and Processes Division we included the representations and transformations of information structures along with theoretical models for such representations and transformations. In the Information Processing Systems Division we were concerned with systems having ability to transform information. Such systems usually involve the interaction of hardware and software. Our Methodology Division was derived from broad areas of applications of computing which have common structures, processes and techniques.

The same Report in its discussion of Masters Degree Programs listed the areas of concentration as:

THEORETICAL COMPUTER SCIENCE

APPLIED SOFTWARE

APPLIED HARDWARE

NUMERICAL MATHEMATICS

INSTRUMENTATION

INFORMATION SYSTEMS

These areas of concentration may look somewhat arbitrary, but actually are the result of discussions by many representatives from many different colleges and universities; and, as such do represent a very good cross-section of what is actually happening in these programs. Needless to say, most universitites come up with their own classification scheme which is partly a function of their staffing capabilities. This of course highlights the standard problem of whether or not to build your staff to fit the curriculum you want to develop; or whether you build your curriculum based on the staff you have to start with. I strongly suspect that most programs in their development at some time or other subscribe to each of these approaches.

One of the problems of computer science or information science is in the implementation of the curriculum. In particular, where should it be administratively located within a university? One thing is clear -- it should be an independent academic unit in order to be able to flourish. If it is not an independent unit, it may well suffer in the allocation of resources, such as personnel, budget, space, and equipment. It is also clear that such an independent unit should be in a position to provide service courses to other parts

of the university. The majority of computer science programs are located within Colleges of Arts and Sciences or their equivalent. This is not universal however. In some instances the computer science department is located within the division of mathematical sciences. A number of computer science programs are located within departments of electrical engineering. In some instances departments of electrical engineering have changed their names to the department of electrical engineering and computer science to indicate their close affiliation. Generally speaking, however, these latter programs are closer to the hardware side of computer science, whereas the computer science departments located in Colleges of Arts and Sciences are much closer to the software side of computer science.

In the light of recent developments in computer science and the many applications of computers that are emerging, it seems that it would be appropriate to have a separate division or school of computer and information science. Such a division could well have a sub-group emphasizing the software aspects of computer science; another sub-group emphasizing the hardware aspects; and still another sub-group emphasizing what might be called the library aspects of computer science. It is clear that library sciences will have to become more and more concerned about the use of computer science in their discipline. Some have suggested that such a broad division should also include a sub-group for information systems management. Others have suggested that the department of linguistics could be included in such a divisiion. It is clear that there are a number of areas which are so dependent on information processing that they could well be lumped together in some new administrative complex. It is not clear however whether all of

these people would be willing at this time to live together in such a division. I hope that this Conference can make contributions in this general direction.

Another major problem in curriculum development is meeting the necessary staff requirements. In the last few years it has been very difficult to obtain well-qualified people in computer science. Fortunately computer science curriculum has recently developed sufficiently well that a relatively large number of Ph.Ds in computer and/or information sciences are being awarded. I strongly suspect that even this coming spring, most departments will have a reasonably wide selection of people to choose from in developing their staff. A few years ago it was necessary to hire personnel whose original degrees were in mathematics, electrical engineering, library science and others. It will now be possible to hire the computer and information science graduates. I sincerely hope that we do not get caught in the trap of reproducing ourselves to such an extent that we become a glut on the market as has been the case in mathematics, physics and some other subjects.

Another problem closely related to the staffing problem mentioned above is that of student enrollments. Most new computer and/or information science departments have been faced with very heavy enrollment figures which has served to compound the staffing problem. It would be necessary that we look at this problem very carefully in the next few years. One solution to this problem may well be attempting to keep the quality of our programs sufficiently high so that our number of graduates does not exceed the demand. Certainly many schools already have strengthened their entrance requirements in this connection. Firm statistics are not yet available as to the number

of departments now in existence. It seems, relatively clear however that there are over 100 departments offering undergraduate degree programs and close to 100 offering graduate degree programs. This too compounds the possible problem of graduating too many students in the computer or information sciences areas.

Still another problem associated with appropriate curriculum development is that of obtaining appropriate physical facilities. I merely want to call attention to this point and to emphasize it may I call your attention to the fact that summer before last, at the World Conference on Computer Science Education, one of the objectives stated for computer science programs was that they should move toward having their own computer for classroom work, experimentation, and research. I feel most large universities are already moving in this direction, but of course are being considerably slowed by the financial crunch.

Another aspect that needs discussion is the relationship between the computer science academic program and the computer center within the university. Next week at the Fall Joint Computer Conference I am a member of a panel that will be discussing precisely this problem. In most universities the academic program and the computer center are now separate. In some instances the relationship between the two is extremely amiable. In other instances there has developed a strong competition or jealousy between the two. This is of course very unfortunate and should be guarded against at all costs. At my university we are still in the same unit and are thus able to avoid the competition and jealousy problems. It is clear that under any circumstances these two units serve a complementary role and should coordinate their efforts in every way possible for the good of both.

CURRICULUM 68 is still under constant review. The World Conference on Computer Science Education recommended that the Curriculum Committee on Computer Science (C^3S) of the Association for Computing Machinery (ACM) look at CURRICULUM 68 and up-date it in view of actual experience with it. Discussions have been held with the National Science Foundation relative to getting monies to help with this review, but to date there has been no encouragement for any monies. There will be, however, a day set aside prior to the forthcoming Fall Joint Computer Conference for a review of CURRICULUM 68. It is hoped that this will lead to further discussions. It has been clear, even from the date of publication of CURRICULUM 68 that some areas of concern in the curriculum were more in need of work than others. Numerical Analysis for example was a well-developed field. The area of programming languages is beginning to be much more definitive at this stage. Systems programming on the other hand is still in a very tenuous state and needs considerable attention including new textbooks.

COMPUTER SCIENCE CURRICULUM DEVELOPMENT at the UNIVERSITY OF MARYLAND

Curriculum development at the University of Maryland was greatly aided by the fact that three members of the C^3S of ACM were actually at the University of Maryland. During the school year 1966-67 a complete Masters Degree Program in Computer Science was developed at Maryland based primarily on the work of C^3S. While CURRICULUM 68 contained only an undergraduate degree program, with brief discussions of programs at the Masters and Ph.D. level, it was possible to rework the curriculum material in such a way as to develop a Masters Program. Maryland and many other institutions were faced with the

problem of accepting as graduate students into computer science people who did not have a Bachelor's degree in computer science. This posed considerable difficulty in attempting to bridge the gap and make certain that graduates with Master's degrees in computer science were at a comparable level with students who received Master's degrees in other subjects, such as math, physics, etc. This meant that most students would basically have to take a large number of courses at the undergraduate level before being accepted as full-fledged Master's candidates. Our entrance requirements initially required that students have at least one mathematics course beyond the calculus sequence; and have three graduate/undergraduate courses in science or engineering. This requirement along with taking the undergraduate courses in computer science placed a heavy burden on incoming students. This was necessary, however, due to the lack of an undergraduate degree. Our entrance requirements have now changed very significantly since more students are now available at the Bachelor's level with backgrounds in computer science. We now have a requirement of at least three undergraduate/graduate courses in computer science before they are accepted as full-fledged students in our Department.

I mention these entrance requirements because they are a major problem related to curriculum development and implementation. I think it is fair to say that entrance requirements have become a bit more stringent in view of the tight money situation within the University. Put another way, it says that tight budget restrictions force us to decrease enrollments, which gives us an opportunity to increase the quality of our student body.

Maryland wrote its Ph.D. Proposal and Program mostly during the calendar year 1968. The major problem in developing this program was matching our

curriculum to our staff. That year and the first few following years were difficult times to obtain staff members who had majored in computer science. The major areas for our program which we were in a position to staff were called:

1. Theory and metatheory
2. Information processing
3. Computer systems
4. Numerical methods
5. Applications

Currently, however, we call our areas of specialization:

1. Applications
2. Computer Systems
3. Language and Information Processing
4. Numerical Analysis
5. Theory of Computing

During those early days of our program, some members of our staff described our program like a doughnut -- we were real good in the peripheral areas, but fell short in the center. I am pleased to report that we have filled in the center of the doughnut and have a sufficient number of people on our staff in the programming languages and related areas.

One of the problems in developing computer science curriculum on the University campus is appropriately relating your curriculum to other departments. There is always a fear that you may infringe on their rights. Thus a very careful coordination is needed. This however can be achieved by interaction with these various departments. In both instances of our Master's Proposal and our Ph.D. Proposal at Maryland, it was necessary that these Proposals be forwarded to the School of Library and Information Services, the Electrical Engineering Department, the Physics Department, the Mathematics Department and the College of Business and Public Administration in

order to get their approval and suggestions. In almost every instance suggestions were made which led to modifications of our program. In some instances this actually caused a major delay in finishing our Proposal. I feel however that in the long pull the suggestions made by these other departments were necessary modifications which made our curriculum fit better into the University picture.

An additional stage in approval on campus is getting it through the appropriate campus curriculum committees. On our campus, such committees are known as PCC Committees -- Program, Courses and Curriculum. The problems that we had to confront with this group were:

1. Increase the flexibility of our program from the students point of view.

   I think it is well-known that in recent years there have been multiple efforts to take into consideration student's plans and to permit students a wider flexibility in the preparation of their programs.

2. Be sure that the student starts with his research at the earliest stage possible.

   Here again in recent years there has been a tendency to provide research programs even for undergraduate students.

3. The display of adequate sample curricula.

   This involved laying out possible curricula for students coming from different types of backgrounds and for students with different levels of previous preparation. Here again I believe that it is very helpful to have general university committees checking on the overall quality and structure of programs. I will admit however that during the process of approval I personally was not enamored with the possibility of having to go through eight levels of approval.

One other point in curriculum development worth mentioning is that in most instances schools will send their curriculum to representatives of existing departments at other schools to get their comments. This is a standard

procedure and frequently improves the quality of the program. Another point in a similar vein is that frequently visiting experts from the outside are called in to go over the curriculum under development. So many times this outsider can come in and quickly spot flaws that have been overlooked by local faculty in their eagerness to get the curriculum approved.

INFORMATION SCIENCE CURRICULUM DEVELOPMENT at the GEORGIA INSTITUTE OF TECHNOLOGY

Finally I would like to make a few remarks about the early stages of the development of the curriculum in information science at the George Institute of Technology. This started in the early 1960s when there was very little else to draw upon. We held two large Conferences at which we brought information science specialists to the campus to discuss curriculum development. Also, those of us attempting to develop the curriculum made many visits to different institutions which were carrying out different parts of what might be an information science curriculum. At the visited institutions we would spend a great deal of time picking the brains of the experts at that place. Our local Georgia Tech Committee was also amplified by members from other universities -- some on a continuous basis and others on an occasional basis. From the ideas obtained from these sources, as well as working closely with the appropriate departments at Georgia Tech, we came up with the first curriculum in information science there at Georgia Tech. Even at this time there was a very difficult problem of making sure you did not infringe upon the areas of other departments. As an example, I vividly remember discussions about artificial intelligence with the psychology department. There were also discussions with the mathematics department who had originally initiated some beginning courses in programming which posed a problem on coordination of this type of course and its extension.

Fortunately there was no Library School at Georgia Tech, so there was no problem in this area.

Curriculum development has been a challenge for years and will continue to be a challenge. It will require tireless efforts on the part of not only those of us at this Conference but many others as well. It is well-known to all of us that the only stable thing in our society is that it is constantly changing. This is certainly true of curriculum. C^3S is continuing its efforts as I have indicated to you earlier. While its early efforts were devoted to the undergraduate program, it is now attempting to work in the graduate area. It has some hopes of financial support in this area and almost no hope of financial support in the undergraduate area. The scarcity of possible grant funds will only add to our difficulties in curriculum development. We must not be discourage however by this possible lack of funds. I feel very strongly that the type of curriculum discussions being undertaken at this Conference should clearly be pursued. I have been an advocate of a broad base for information science development for many years and I see no reason for changing this position. I hope that this Conference and the ideas that come from it will move us closer to this broader base which so many of us feel is necessary. It is clear to me however that this is an even more difficult task than that undertaken by C^3S in its development of computer science curriculum. This does not in any sense however minimize the importance of this challenge to build better information science curriculum.

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A MULTI-MEDIA APPROACH TO TEACHING THE USE OF INDEXES

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ABSTRACT

Instructional materials prepared for teaching the use of indexes are a programmed text, taped lectures accompanied by sample indexes, and a demonstration of an on-line searched index. Sample indexes searched by the student are a printed coordinate index, an optional coincidence coordinate index, a coordinate index on edge-notched punched cards, an on-line searched coordinate index, and a key-word-in-context index. The material is used in a three-weeks segment of an introductory information science course. The development and use of the material are discussed.

Introduction

This paper will discuss the development and content of a three-weeks segment on indexes in an introductory information science course. The educational objectives, factors that led to the development of the instructional materials, a description of the materials, and comments on their use will be covered. There are antecedents to this project. The following reports of work in which classroom lectures were supplemented or replaced by other methods of instruction stimulated our work along these lines: the summary of the literature to 1967 on new instructional aids for teaching library science by Wendt including his own work

with programmed instruction for teaching the use of library materials to college freshmen (1). Batty's use of several types of indexes to small collections of documents as an aid in teaching (2), the work of the University of California's Institute of Library Research with computer-aided instruction for teaching associative retrieval and subject cataloging (3), and Caruso's use of computer-aided instruction for teaching the principles of file searching (4).

To set the stage, I will begin with a few words about the introductory information science course that contains the unit of indexes. The course, referred to from now on as LIS 586, is a three quarter hour required course for master's students in library science at Florida State University. The course is offered every quarter (four times a year) and has a typical enrollment of 30 to 50 students per quarter. One-third of the course (about three weeks) is devoted to systems studies in libraries, one-third to equipment used in libraries, and the remaining third to indexes. Students interested in learning more about indexes may select another course, Abstracting and Indexing, after completion of LIS 586. In the abstracting and indexing course, unlike in LIS 586, the emphasis is on the preparation and evaluation of abstracts and indexes.

Educational objectives

The educational objectives of the section on indexes in LIS 586, stated in general terms, are to increase the student's proficiency in the use of indexes. All of our graduates are

likely to make extensive use of indexes to document collections, to data collections, and to records needed in operating a library. Reference librarians will not only use such indexes, but also teach others how to use them. Some librarians may also have to prepare indexes, but this section of the course is not intended to teach the required skills since the emphasis is on the use rather than the preparation of indexes. More specific educational objectives are listed in Table 1.

TABLE 1. EDUCATIONAL OBJECTIVES OF THE INDEX SECTION IN LIS 586

* to become acquainted with steps in index preparation and use
* to learn about types of indexes, components of indexes, and index variables
* to gain an understanding of problems in index design, preparation, use and evaluation.

At the conclusion of the course, students should be familiar with the types of indexes mentioned in a later part of this paper. They should also recognize important index variables such as elements of vocabulary control and depth of index. In the case of coordinate indexes, for example, students should be able to select indexable information from a question, translate the indexable information into the language of the index with the aid of a subject authority list, formulate search statements, manipulate the index apparatus, and make relevance judgements on documents retrieved. Inability to predict how and how frequently an index will be used, bringing the language of the index user in coincidence with the language of the index, and the subjective nature of relevance judgement are examples of problems with indexes with which students should be acquainted.

Development of instructional materials

The development of instructional materials was an evolutionary process. Dissatisfaction with the presentation of the material led to modifications, and these modifications were in turn revised. Thus the original lecture presentation was supplemented by demonstration of indexes in class. These in turn were revised and supplemented by classroom exercises in the use of the subject authority list and indexes. The multi-media approach described in this paper represents the latest stage in this process for the LIS 586 section on indexes. Two factors in addition to dissatisfaction with previously used methods and the work of others cited in the introduction stimulated the development of the multi-media materials: an opportunity to prepare an on-line searched coordinate index and the interest on the part of one of our doctoral students in comparing multi-media with traditional methods of instruction.

The preparation and use of the on-line searched coordinate index, called FOCUS (Florida State University On-line searched Coordinate Index Use Study) are described in two technical memos (5,6). FOCUS is an index to over 1800 documents on systems studies in libraries, equipment used in libraries, and indexes - the topics dealt with in LIS 586. FOCUS is searched on-line (but not in real time) on an IBM 1500 system located at the University's Computer-aided Instruction Center. Search statements with thirty or more descriptors connected with "and" and/or "or" and/or "not" logic can be handled by the computer. The computer's initial response on the cathode ray tube is the number of potentially relevant documents that meet the search specifications.

The searcher then has the option of reformulating the search statement if either not enough or too many potentially relevant documents have been selected or he can ask for a display of the document surrogates. Document surrogates are either full bibliographic citations or document accession numbers. Another search option is to search either the entire data base or a specified portion thereof. The index vocabulary for FOCUS is controlled via a subject authority list which is in printed form. Other components of the system are an abstract bulletin in which the indexed documents are listed by document accession numbers, a computer-printed manually searched coordinate index in which document accession numbers are posted by terminal digit and in ascending order on descriptor units, computer-aided instruction for index preparation and index searching, and a programmed text on index searching. Portions of FOCUS dealing with index preparation are used only in the abstracting and indexing course.

One of our doctoral students, Miss Drucilla Motley, selected for her doctoral research the comparison of the traditional lecture/exercise method with a computer managed multi-media approach for teaching the LIS 586 index section. She characterized the educational objectives of the section on indexes in terms of concepts, principles, and problem solving to be learned, and developed her teaching materials in terms of these objectives. Her instructional "package" consists of computer-aided instruction, a programmed text, a conventional text, slide-tape lectures with index searching exercises and the instructor serving as resource person at small group discussions. Parts of the instructional

materials developed by Miss Motley for her dissertation are now used in LIS 586 on an operational rather than experimental basis. These are the programmed text and three taped lectures/exercises. The other two taped lecture/exercises were prepared subsequent to her work. She found no signigicant difference in pretest to posttest score gains between the two methods of instruction. Miss Motley has collected a considerable amount of data other than the pretest/posttest scores in the course of her study, data that will be reported in her doctoral dissertation.

Description of instructional materials

The instructional materials not in use are listed in Table 2. Students are introduced to the section on indexes at a classroom lecture. At that time the objectives of the course segment are given, terms are defined, steps in index preparation and searching are discussed, and a handbook is given to each student. The handbook gives directions and necessary instructions for the individualized lessons and the on-line searched coordinate index demonstration. The handbook also contains a list of readings to be done before the individualized lessons, and handouts to be used with some of the lessons. For example, illustrations of the mechanics of searching edge-notched card decks and questions to be searched are included for the lesson on edge-notched punched cards.

Students begin the individualized instruction with the two lessons on topics they need to understand for searching coordinate indexes: the subject authority list and search logic. These two lessons are followed by the four taped lecture/exercises and the readings on indexes lessons, which can be selected in any order.

The demonstration of the on-line searched coordinate index comes next and is followed by a concluding lecture and an examination. For the subject authority list taped lecture/exercise lesson, the student has a copy of the subject authority list in front of him while he listens to the taped lecture. The lecture covers reasons for using a subject authority list, its structure, and component parts. The lecture directs students to specific pages of the subject authority list for illustrative examples. In the exercise part of the lesson, students are asked to translate indexable information into descriptors with the aid of the subject authority list. They are then told the correct answer and why this is so.

The taped lecture/exercise on edge-notched cards is accompanied by a sample deck of edge-notched cards and sorting needles. The deck represents a data file, an index to employee characteristics in a hypothetical company. Each employee is given a serial number and there is one card per employee. On this card are are written and coded the employee's characteristics, as examplified by place and date of birth, level of education, foreign language skills, and subject specialization. These characteristics are encoded with either a direct or an indirect code. The taped lecture covers basics of coding and searching decks of edge-notched cards, principal variables, as well as advantages and disadvantages of such indexes. The student is instructed to conduct several searches of the deck that is in front of him. Searches illustrate different logical search statements, different types of codes, and false drops. The correct answer for each

search is given. The tape lecture/exercise on the printed coordinate index uses the computer-printed manually searched index component of FOCUS mentioned previously. The optical coincidence index taped lecture/exercise is to a sample of documents indexed in FOCUS. The keyword-in-context index to the literature on information retrieval and machine translation compiled by Balz and Stanwood (7) is used with the taped lecture on keyword from title indexes. Each of these lessons is similar in content to the edge-notched card lesson. The mechanics of searching are explained and the principal variables, advantages, and disadvantages are discussed. The student is then given practice searches and is told what documents should have been retrieved. Students are encouraged to see the instructor whenever they have questions or difficulties with the material.

During the half hour demonstration of the on-line searched coordinate index at the Computer-aided Instruction Center, students are taught how to sign on at the computer console. Each student is then asked to conduct three searches of varying complexity. For the first two searches the descriptor code and search logic are given. For the third search the student has to use the subject authority list and select the appropriate logical connectors. If time permits, students can make additional searches on topics of their own choice. Execution of the sign-off routine completes the demonstration.

Two of the topics, alphabetic subject indexes and citation

indexes, are covered primarily by readings. The concluding lecture before the examination deals with index evaluation and is a review of material covered. The examination for this segment of the course consists of objective questions about the types of indexes and index variables studied and an index search exercise. For the search exercise, excerpts of the subject authority list are distributed to the student and he is asked to select indexable information from a question, translate this indexable information into descriptors with the aid of the subject authority list excerpt, and formulate a search statement.

TABLE 2. INSTRUCTIONAL MATERIALS FOR SECTION ON INDEXES

a. Student handbook
b. Search logic - programmed text and other readings
c. Subject authority list - taped lecture/exercise and readings
d. Printed coordinate index - taped lecture/exerices and readings
e. Optical coincidence index - taped lecture/exercise and readings
f. Edge-notched card index - taped lecture/exercises and readings
g. Keyword from title index - taped lecture/exercises and readings
h. Alphabetic subject index - readings
i. Citation index - programmed text and other readings
j. On-line searched coordinate index - demonstration

Conclusions

The teaching materials described are now being used for the second time on an operational as contrasted to an experimental basis. Miss Motley's previously mentioned study and a review of similar

studies by Dubin and Taveggia (8) lead me to believe that learning will not be improved with the multi-media method, at least not in ways that we can now measure. There is, however, an indication that students prefer the multi-media approach. An opinion study of the 40 students in the LIS 586 multi-media section on indexes in the 1971 summer quarter indicated that 34 out of 40 students preferred slightly or greatly the multi-media over the lecture method. This might be due to several factors. Index use is not a spectator sport and is probably easier to learn by doing. The multi-media approach affords greater flexibility in when and how the material is used. Thus each student can use the material in accordance with his schedule rather than a fixed classroom schedule. This, incidentally, was not considered an advantage by all students. Some prefer the imposed discipline of the classroom schedule. Students can also use material at their own pace and for as many times as desired. The material is available to review for the examination. The advantage of the multi-media approach for the instructor is that it makes time available for other tasks. Time saved on formal lectures might be used for discussions with individual students. Whether teachers would miss live performances before large groups only time will tell.

Problems with the material described have been minor up to now. One tape developed surface noise after about thirty uses. We keep a master copy of each taped lecture and are able to make working copies with little effort. The deck of edge-notched cards also showed signs of wear after about thirty uses by inexperienced

needlers. Cardsavers (gummed paper placed over the damaged portion of the card edge) solved this particular problem.

The development of teaching materials is a time- and energy-consuming process. This suggests the potential benefit of formalizing the sharing of such materials among teachers in our field. Let me therefore propose that we study the desirability, feasibility, and mechanism of such sharing. Perhaps some day in the not too distant future we might have a clearinghouse giving description and availability of slides, tapes, films, computer-aided instruction programs, sample indexes, reference questions, and other teaching materials that we may obtain from each other.

I would like to conclude by acknowledging the contributions of several people to the work reported: Dr. Duncan N. Hansen, the Director of the Florida State University Computer-aided Instruction Center, for both his encouragement and the resources provided; Mr. Tom McMurchie for computer programming; Miss Drucilla Motley for the programmed text and the taped lecture/exercises on the printed coordinated index and the optical coincidence index; last, but not least, Mrs. Ferol A. Foos for her invaluable assistance in all stages of development of FOCUS.

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DIRECTIONS IN EDUCATION FOR INFORMATION SCIENCE:

THE RATIONALE AND PLANNING FOR AN INFORMATION SCIENCE COURSE IN A "FOREIGN" DISCIPLINE: MEDICINE

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Introduction

As offered today in educational institutions, Information Science can be a recognized and approved program in a School of Information Science, a program or courses within a library school, departments of computer sciences, engineering or behavioral sciences, or a course within a professional school curriculum. This paper is concerned with Information Science given as a course within a professional school, specifically a medical school. The inclusion of Information Science courses within professional schools is one direction to be considered in discussions of Education for Information Science. The position advanced here is that knowledge of Information Science should be diffused as widely as possible by including such courses in graduate educational programs of other disciplines.

This paper is divided into three parts: a rationale and philosophy of planning; one example of planning with the construction of a course; and possible future directions.

Part I.
Rationale

In the past several years, courses in Information Science or some aspect of documentation have been given in a number of universities and continuing education programs to biologists, chemists, and engineers. Several papers have been written describing the need for

and the conduct and evaluation of such courses.[1-6] User training has been recommended and encouraged by such groups as COSATI and the Office of Education.[1] Yet such courses seem to be the exception rather than the rule. These courses appear to be offered where there is an individual motivated to plan and conduct such a program or where a professional society sponsors such a series. Many of the papers stress the need for such material to be offered but few devote attention to the philosophical aspects of planning. What this paper will try to accomplish is the exploration of some of those philosophical aspects. It is hoped that this material will stimulate some further discussion on course planning in a "foreign" discipline; and that information scientists and educators will actively plan courses to be made available nationally in all university professional schools. A missionary goal, perhaps, but certainly one to be considered seriously.

Why a course in Information Science in a professional school? There are at least three reasons. First, Information Science has had an impact on the educational and information transfer practices of several professions including Medicine, and has affected the way students and practitioners obtain, use, and produce information. Second, the total impact of new technologies makes it logical if not advisable for the students and practitioners to use available tools and services directly rather than through surrogates such as librarians or information specialists. Third, to paraphrase Clemenceau, Information Science is too important to be left to the information scientists;

it should be diffused widely within other educational programs and made as relevant as possible to those programs.

Consider the KWIC indexes, the SDI systems, information centers, and computer retrieval systems, the remote ones such as MEDLARS and those with on-site terminals such as AIM/TWX. These relatively recent innovations are just a few of the Information Science developments that are available, have been accepted, and are used today by a slowly growing number of people in Medicine and other fields. The ready access to information and the changing requirements for publication (provision of abstracts and keywords with a manuscript) are but a few of the information handling techniques making an impact on the engineer, the chemist, the medical student, and the clinician.

The Panel on Education and Training of COSATI[1] and groups of medical educators[7] have agreed that the available tools and services are best used directly by the practitioners of a profession. These professionals should know what sources are available, how to use them, and how to innovate, perhaps in collaboration with an information scientist, to obtain even more useful information retrieval systems and transfer devices.

The body of knowledge that is Information Science is not confined to use in Information Science. It is already a part of the practice of and applied to the products of other disciplines. Professionals in other fields, specifically Medicine, are vitally concerned with the handling of their information. If they do not learn principles and

procedures during their student days, then they must be re-educated on the job to perform some of the functions that relate to the broad spectrum of information handling (evaluation, storage, transfer). That is one of the principal reasons for Information Science to be taught in professional schools. This is not unlike Medicine's position to impart basic concepts to other programs starting with hygiene in the public schools, first aid in adult education courses, and reaching to such formal disciplines as biomedical engineering.

So much for the rationale. Assuming one accepts these reasons, let us move on to some fundamental theories related to the planning of such a course in a professional school.

When a course in Information Science is planned for inclusion within the framework of the curriculum of another discipline, what are some of the considerations?

They include:

1. The comprehensive or global view to identify concepts, purposes, and functions

    A. A description of the host (H) discipline

        1) Characteristics

            a) Organization
            b) Needs and goals
            c) Personality and cultural attitudes
            d) Assessment of information patterns

        2) Educational objectives and specification of terminal behavior[8]

            a) What changes are to be effected? (Identify desirable improvements)

b) How will this be done?
c) What must be taught?
d) What are the expectations of success?
e) How will you know when you have taught it?
f) What materials and procedures will work best to teach what you wish to teach?

B. A description of the donor (D) discipline

Characteristics

The array of substantive areas of knowledge and techniques

2. The local view

A. The Interface

1) Substantive areas of D of educational interest to H

Course emphasis depends on

1) Contexts
2) Objectives
3) Capabilities
   (a) Political
   (b) Practical

2) Organizational choices; orientation by

a) Form of the material to be taught
b) Needs of the user groups
c) Types of approach (conceptual, empirical, procedural, stimulatory,[9] design and analysis, policy)

3. Construction of a prototype to test scope, direction, and form within a specific environment

4. Interpretation of use of prototype

5. Synthesis of information gained from prototype; iterative test process

All of the preceding will be examined here, but the primary focus will be on the theory of the environmental. -

The examples for all speculation and recommendation will come from

a course that was planned, developed, offered, and given. This course, Information and Communication, was accepted as an elective in the curriculum of The Johns Hopkins University School of Medicine.[10] Medical students who took the course for credit attended lectures and tutorial sessions. All interested members of the biomedical professions were welcome to attend the lectures. All participants, students who enrolled in the course as well as people who attended lectures only, evaluated the program immediately after the last lecture; the impact of the course on all participants was investigated one year later. Evidence indicates that many of the course objectives were achieved. Though the paper refers to a medical school environment, the principles offered here should be applicable to other environments.

A Philosophy of Planning

Because Medicine lives intimately with information and because part of Information Science teaches how that intimacy can be achieved most effectively and enduringly, we should see how to engage the two disciplines. The engagement process is one way to look at the fundamental problems that affect the orientation of an Information Science education program when it is offered within the framework of another discipline.

Environmental Considerations: Two Views

To develop a course in Information Science within the field of Medicine, it is useful to have a clear conception of what Medicine is

and what Information Science is and where the interface is located. This would be true in any similar situation no matter what the disciplines. Because both Medicine and Information Science are in a dynamic stage of development, it is necessary to be aware of needs present and future, to generate ideas of how to meet these needs, and to continually refine short and long-term objectives and goals. In addition, it is useful to develop a prototype or model to test the scope, direction, and form of the material within a specific context.

Let's look at the environmental relationship two ways: comprehensively in terms of concepts, purposes, and functions; and locally in terms of schemes, means, and tools for solving specific problems.[11]

The comprehensive view attempts to display the broad characteristics of a field and its interfaces and relationships with other fields. The local view concentrates on the inner structure of the field. To cite an example: on the comprehensive level an interaction exists between Medicine and Urban Planning, Medicine and Economics, Medicine and Statistics. This interaction is a global one concerned with relationships and classes of problems that these relationships invite. At the local level, in contrast, each is concerned with the kinds of knowledge, problems, and activities that exist within the discipline as well as the working relations between them.

The Comprehensive View.--In the musical "Music Man", the one condition for success was "You gotta know the territory." This is a very basic, very important consideration: to successfully transplant a

course in Information Science to another environment, it is necessary to know the territory. To put this on an abstract level, in any bi-disciplinary activity where material of discipline D such as Information Science is introduced into the curriculum of a traditional or well-established field such as Medicine (discipline H), it is of prime importance to understand certain basic fundamentals and operations about that environment. Among them are 1) the organization of discipline H (the host or subsuming discipline), 2) the needs and goals of that discipline, and 3) the personality of the field as shown by the students, graduates, and faculty.

Of discipline D (donor) it is also obligatory to know the comprehensive view. What are the present needs of Medicine (discipline H) that can be met by Information Science (discipline D)? What are the new areas in Information Science that can help solve some of the as yet generally unrecognized problems in Medicine? What is feasible to introduce and incorporate in Medicine's practice? What is a useful technique but not yet feasible to introduce?

Why does discipline H need discipline D? That need must exist or there is no reason for the engagement of D to H. If it does not exist, the students in H will consider the material of D non-relevant and not worthy of their time or attention and will reject the transplant.

As we have stated, Medicine is a discipline clearly wedded to information. Such information is generated by basic researchers, clinical investigators, and health planners. Patient information is stored in

the medical record, and, in addition to being used in the care of the patient, is used for the education of the student at all levels: undergraduate, graduate, continuing education. In addition, there is a strong analytical and synthetic orientation in the handling of this information. Students, educators, practioners, and researchers examine, interpret, compact, and combine it to provide new information.

In the recent past, Medicine has been a formally organized field structured according to discipline (such basic sciences as anatomy, physiology, and biochemistry,and such clinical sciences as medicine, surgery, pediatrics, and psychiatry), and arranged hierarchically by the participants' levels of competence (students, house staff, generalists, post-graduates, and specialists). It is oriented three ways: patient care, education, research. For its practice it requires hospitals, laboratories, records. Its literature is vast, and the new amount of information being published is prodigious.

How might the field change tomorrow? Next year? Five years from now? The block curriculum in medical schools is being replaced by an open, more flexible, and more complex curriculum which is leading to a more individually tailored course for each medical student.[7] Success with such a program can be realized only if students have at their disposal methods which give to each student access to that information he needs. Techniques for transmitting the available knowledge and for devising new communication methods to allow students to acquire skills independently are mandatory. Students will also have to acquire

familiarity with those techniques through which effective continuous self-learning must occur. The relation of the rapidly increasing amount of information to the necessity that each physician acquire the ability to keep himself up-to-date has been stressed often. More extensive application of educational and communication technology early in the course of medical education is not required tomorrow but today. The Information Science taught to the medical student today must include making him know about and use such devices as AIM/TWX (Abridged Index Medicus) and computers; must offer him principles of systems design for organizing and maintaining his own files and integrating these where possible with the developing biomedical communication networks. The day will come that "...as the physician actually records his data and plans the treatments, the very communication tools he uses will have built into them the parameters of guidance and the currency of information he needs to define and solve problems."[12] It is not a mere dream to expect that data collection sites, neighborhood health centers, and specialized health centers will be joined by a computerized record system so that in no area of the country would a patient's problem be dealt with in ignorance.

The field of Medicine is characterized by intelligent, busy people working almost constantly amid stresses and strains -- their own busy schedules, the problems of the people they seek to care for, the constraints of the social system, the burgeoning amount of published information in all facets of their work, and the changing practice of medicine. Busy people want information quickly, succinctly, and with no

nonsense. Such information must be relevant and useful, valid and workable. They come to lectures not to be amused but to learn so that they might perform their own duties more efficiently.

The Local View.--While the comprehensive view looks broadly at phenomena and concepts, the local view is concerned with the ways and means discipline D can solve particular problems in discipline H. In our example, Medicine's needs, types of performance, and objectives which were obtained from the comprehensive view helped select those specifics that went into planning the Information Science course for Medicine.

The choice of which specifics to include and for whom and when and how to include them are the responsibility of the people planning the program: the Information Science teacher, members of the medical faculty, and the students. The Information Science specialist should draw on his experience with discipline H and, in light of the needs of the field, examine the spectrum of Information Science to determine which aspects to include.

ASIS has defined information science as being concerned with the generation, collection, organization, interpretation, storage, retrieval, dissemination, transformation, and use of information.[13] As we have seen, people in Medicine participate in the information spectrum from the generation of information through its collection, interpretation, and use, and its subsequent storage and retrieval to the preparation and publication of papers. In our course, all these aspects of Information

Science were included.

Political Considerations

In addition to the previous considerations, the views of individual faculty members are important factors in the acceptance of a new educational program. Certain faculty members are always more eager to embrace new ideas than others. The planner of a program of Information Science in Medicine -- or any D discipline to be offered in H -- should seek out the "willing to listen" faculty and use this resource fully.

In a medical school the faculty and students are critical of any material not directly concerned with the core medical program. There is stiff competition among departments who are vying for time to get their courses into the curriculum or to obtain additional hours. The curriculum committee must be convinced of the value of the course. The content of the course thus must be relevant. Also, the presentation must be professional and medical in example.

The host faculty should cooperate in the selection of the actual content of the program and wherever possible, should participate in the presentation of lectures or workshops. In a survey of university instruction in the use of the chemical literature in universities in Europe, Bottle[3] reported that European practice differs from that in the United States in the almost complete lack of participation in the courses by librarians. He states that "the literature exists for using, and, as there will be more chemists using it than librarians conserving

it, it is perhaps unfortunate when chemistry students are not given most of the course by chemists with considerable knowledge of the literature, but are taught entirely by librarians with considerable literature knowledge but little or no experience in practicing chemistry." Yet Wyatt and Bottle[6] suggested that information scientists should conduct such courses.

Students, of course, also have a role. They have displayed an increasing concern and involvement in the educational process that serves them. The results of a periodic assessment of their needs and their reaction to an educational program should be reflected in the development of any Information Science course.

Implications for Course Planning.--In view of the previous material we may conclude that it is useful to distinguish between two types of activities that are needed in planning a course on Information Science in Medicine: 1) activities concerned with design principles in planning the course, and 2) activities concerned with the details of what is actually taught.

In planning a course in any field one should organize and arrange the significant knowledge and map this knowledge into a network of inter-related study activities.[11] There is no one method: lecture sequence and content can be arranged in different ways. A description of a course can be partitioned variously. The partitions that we adopted in our course at Johns Hopkins traced the substructures of information handling from locating information to evaluating what was

found to using it for writing and finally to storing it for retrieval. Another arrangement might have been to start with a system study of the field, then discuss the generation of information and its publication, sources for and evaluation of information, and so forth.

Part II.

The Construction and Test of a Prototype

We believed there was a need for a course in Information Science in Medicine. Before we constructed the course content and form, we analyzed and characterized the concepts, purposes, and functions common to the host discipline. The purpose and objectives of the course, the plan of the content, and the sequence in which it would be offered were laid out. We discussed this preliminary program with faculty, deans, practicing physicians, researchers, and librarians. The people we talked with liked the plan and suggested one more topic for a lecture that we had not considered. That addition was a session on questionnaire design -- its influence on eliciting and compiling information. This final course design was proposed to the curriculum committee and approved. It was planned as a lecture series with tutorial sessions.

The course was intended primarily for first year medical students. These students generally have a variety of backgrounds: biology, chemistry, physics, engineering, behavioral sciences, and more, and usually have had no information science courses.

The course as offered was thus the combined thinking of people in

discipline H and discipline D. The program reflected the needs of today and introduced some concepts on the planning board for tomorrow. The latter described new systems emerging and developing. One year later, one of those systems, AIM/TWX, is here, viable, and fast developing.

As offered, the course looked like this:

Course Purpose:

Provide information on

1. Conventional and nonconventional sources of biomedical information
2. their use
3. methods for evaluating the literature
4. principles for scientific writing
5. techniques for organizing information for personal files

Objectives:

At the end of the series participants should better understand

1. the variety of local and national sources available to them
2. how to use these sources for gathering information
3. how to look at the literature critically
4. how crucial a questionnaire form is to eliciting and compiling information
5. how to organize and present material in papers for presentation or publication
6. how to set up and maintain personal files for storage and retrieval of collected information

Plan:

10 one-hour seminars

guest lecturers

Lecture Schedule:

Introduction to Information Handling

Search Strategy for Specific Problems

Search Strategy for Current Information

Credibility of the Information

Questionnaire Design: Its Influence on Eliciting and Compiling Information

Scientific Writing

Personal Index Files: The Intellectual Organization of the Material (Software)

Personal Index Files: Equipment and Procedures (Hardware)

Systems Design

New and Emerging Biomedical Information Services

When the course was over and the questionnaires evaluating the program were received, we learned that the Introductory Session which had been planned to give the rationale for the course was superfluous. Much careful planning and rehearsal preceded this session. It was introduced by the Dean for Student Affairs; it was conducted by one medical student, one house officer (a resident), and one faculty member to explain their needs and uses of information. Several students recommended in their questionnaire replies that this session be omitted. Herner[1] had a somewhat similar experience in giving a course to engineers and scientists.

The participants in our course wished to begin to learn the specifics immediately. However, if such a session had not been included, perhaps the attendees would have pointed to the omission. The principle here seems to be that even when you have the local authorities advise you, you may go astray. On the whole, though, the local authorities are important and should be consulted frequently in planning such a course.

When introduced into a "foreign" curriculum, a course in Information Science should be as flexible and as varied as possible to meet the needs of that discipline as broadly as possible. We tried to follow this approach by announcing to graduate students, faculty, administrators, and nurses that all interested members of the biomedical professions were welcome to attend the lectures.

Practical

A few practical suggestions are offered here for those with pioneer spirit, guts, humor, and determination who might wish to undertake a similar program of introducing a course in Information Science into another discipline. These suggestions might be reminiscent of a systems design approach.

1. Know your field (Information Science) and the field to which you are introducing it.
2. Crystallize and verbalize what it is you wish to do. Write the course purpose and objectives.
3. Analyze all phases of the system. Know the users (the students), their existing knowledge of Information Science, their needs for

such information in school and beyond, the changing needs of the field, and the changing tools in the field. Learn the procedures in your university that are necessary to follow to offer the course. Decide what options and facilities are involved (time of year, time of day, length of course, lecture room, lecturers, etc.)

4. List the topic options. One way is to start with the output requirements (the objectives) and determine what topics and procedures are necessary for attaining that goal. Another way is to determine what resources are available and what is required to reach the objectives. Output requirements can be determined by asking a sample of students what they think they need. Input data can be determined by surveying needs and preparing a list of these needs. Again, know the territory; ask, read, use your intuition. Ask yourself what your students will do with the information you give them -- reject it? or consider it interesting? or use it and reuse it?
5. Formulate problems for the students and consider how they would solve them. That will offer other ideas of what to incorporate in the program.
6. Determine the form the course should take. Determine what is already done in the school and the library to achieve the objective you established. Determine the amount of possible duplication with other sources or programs.
7. Prepare a time-table to organize the course. Include time for talking with users, librarians, faculty, students, clinicians, and

researchers regarding content and form, and for problem definition (scope and depth of subject to be covered).

8. Match user requirements with the plan of the topics.
9. Design and synthesize the topics, methods, and facilities needed to fill the requirements.
10. Estimate costs (material to be distributed, honoraria, if any, for lecturers, room rental, projectionist, announcements, etc.)
11. Check with the Administration to see if everything planned is acceptable.
12. Pray for luck.

Part III.

Directions for the Future

We have seen that a number of disciplines sporadically offer courses in Information Science to their students. We have examined a philosophy and a procedure for course planning to aid in the construction and development of such courses. Where do we go from here?

Assuming there is a need for knowledge of Information Science in other disciplines, several types of questions come to mind. What mechanisms are there for providing Information Science guidance and expertise to those schools that wish to offer such courses but have no motivated and capable instructors on their staffs? Assuming there is a motivated individual on the local scene, what guarantee is there that a "core" course would be offered that would be similar to a course offered in another school? As Taylor[14] warned in connection with Information

Science, "...the role of information is too important and our resources too limited to allow haphazard and profligate educational schemes to develop." At what point, if ever, should there be standardization of material? At what level of instruction should the course be offered? Should it be an elective or should it be required? Who should be responsible for the course: should it be offered as an independent activity through whatever department is willing to sponsor it? should the material be integrated within the structure of another course concerned with the subject matter of that discipline? should the material be made available in an audio-visual or multi-media presentation within an independent learning situation? should preceptors be "recruited" to teach the students on an individual basis much as a student research project is handled? The decision of which route to select is probably a matter of climate and practicability. The decision of which topics to include should probably rest with the professionals of the host discipline except to a limited extent, since several reports have shown that the needs of the students and practitioners span most of the information and communication spectrum, although not in depth.

I suggest several directions for active consideration and considered action: 1) the formation of a group under the direction of such committees as the Education Committee or Committee on Inter-Society Cooperation of ASIS to explore the interests of the medical or other professions in the establishment of a "core" program. The SATCOM Report, Recommendation B8 states:[15] "As experience in the operation of need-group

information services develops, a suitable organization, perhaps the American Society for Information Science, should seek support as required...for a program that...will advance know-how and general understanding of the design and operation of such services"; 2) Assuming interest and progress, a suitable group, probably in the host discipline, should recommend such a program to committees of professional groups for approval and recommendation to each school; 3) the publication of papers about Information Science in the professional journals of the discipline such as the Journal of Medical Education. The purpose is to inform the teachers and administrators of medical and other schools of information and communication developments and how they affect the current practice and teaching of medicine and what is needed to keep students aware and participating; 4) urging directors of continuing education programs to include Information Science in their programs; and, perhaps in time, 5) the establishment in medical schools of departments of Information Science or Information and Communication to develop and teach such courses and to conduct research.

Summary and Conclusions

The rationale for including a course in Information Science within the professional program of another discipline includes 1) a consideration of the current impact of Information Science on that discipline; 2) the role of the professional in that discipline in the information handling of that discipline; and 3) the importance of the diffusion of information that is Information Science. Two environmental views are

described as fundamental considerations in course planning: the comprehensive and the local view of the profession into which Information Science is being introduced as well as of Information Science itself. Reference to construction of a prototype is included. The course "Information and Communication" given at The Johns Hopkins University School of Medicine provides an example of the philosophy and planning described.

Conclusions drawn from planning and giving such a course follow. In introducing a course on Information Science to a medical school -- or to any other discipline --

1. Know that other field; know you can justify offering such a course, and know reasons for growth of the field in the past, and present and future trends.
2. Outline the objectives.
3. Discuss the subject and orientation and content with the faculty of that discipline.
4. Plan the structure and details of the course and keep the examples within that discipline.
5. Evaluate the course immediately after its conclusion and six months or one year later.
6. Invest in the course the next time you offer it the information learned from the evaluation.
7. Determine how frequently and to which group the course should be offered.

Postscript and Prescription

An important part of educational planning is to examine continually the existing framework and content of a course with a mind always open to changing this complex so that it will better reflect the current structure and needs of the field. Educational programs are like mosaics. They consist of pieces of information and knowledge. As new information is gleaned, as knowledge grows, one piece or one mosaic is replaced by another. The pattern changes. The process is one of constant comprehensive and redistributed fragmentation.[16] Whether you plan educational programs for Information Science within Information Science or for another discipline, be aware of and willing to make these shifts.

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Curriculum Development for a Broad Educational Program in Information Science*

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ABSTRACT

Information science is defined in precise and analytical terms. Information is defined as data of value in decision making. This definition leads to a descriptive model of a generalized information system of virtually universal applicability. This philosophy and model are used to establish curriculum objectives and goals for a broad program in computer and information science. The objectives of this program are described and specific curricula are given. These programs now exist in the Department of Computer and Information Science at The Ohio State University. These curricula describe both graduate and undergraduate programs. Further descriptive detailed information concering the activities of the Department of Computer and Information Science and other activities on The Ohio State University Campus are presented. A number of experiences from the program are given.

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Curriculum Development for a Broad Educational Program in Information Science*†

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The first step naturally in designing any part of an educational system is the setting of goals and objectives and the consequent specification of subject matter. Therefore, before any curriculum in information science can be rationally developed, there should be a reasonable definition and understanding of what the field is and what it consists of. Although various attempts have been made by a number of people to define information science in the past, none of these definitions has the breadth and the precision necessary to enable the development of an educational program.

In the Department of Computer and Information Science at The Ohio State University, we consider information science to be a broad discipline concerned with the generalized study of information flow. Information is defined as data of value in decision making and a "generalized information system" of virtually universal applicability is accordingly established. We then define computer and information science to be the study of information processing and information flow in this generalized system. These definitions have been used by the

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† This is a summary of a broader and more detailed paper currently in preparation.

authors in other papers (1), (2), (3), and are briefly summarized later in this paper. The primary purposes of this particular paper are to generate guidelines for the development of an educational curriculum beginning from these principles and to describe how these principles and guidelines have influenced the development of our curriculum in Computer and Information Science at The Ohio State University.

Introduction and Basic Definitions

Science is an often used, and frequently imprecisely used, word which has generally lost the specific meaning it once had. Now almost any subject matter area maybe called a science e.g., military science, management science, transportation science, etc. If information science is to be a true scientific discipline, it must satisfy certain necessary conditions. There must of course be a distinguishable and unified body of knowledge. There must as well be some general methods and fundamental concepts which can be applied in most situations. It must be possible to establish and define rigorously the fundamental quantities involved. These quantities should be measurable and capable of a quantification which relates them. There must also be a general theoretical model which serves as a foundation for the science and for determining the range of applicability of the science.

We have attempted to formulate a general theoretical foundation for information science in terms of a model for a generalized information system. Although this model was first developed to describe a military command and control situation (1), it was soon recognized that this model is much more general and highly descriptive

and has virtually universal applicability as well. This model covers all aspects of information including its generation, collection, classification, transmission, and utilization. Most importantly it allows us to define information, to define other important quantities, and to develop general relationships relating to the flow of information. It is appropriate at this time to describe the model very briefly.

This model has four main subdivisions referred to as functions. These are Information Acquisition and Dissemination (IAD), Decision Making (DM), Execution (E) and Transformation (T). Inasmuch as the central function of any system of this type is decision making we consider this to be most important. Information must be used for something. Information is seen to be used in making decisions and is seen to be the only resource available to the decision maker. Data or knowledge are collected, experiments developed, research undertaken, and data evaluated, so that when it is time to make a decision there will be adequate facts and information available to the decision maker. Of the data available to him, the decision maker of course uses only a portion. That portion is what we define as information. Information is data of value in decision making. The specific model used is shown in Figure 1.

The result of the decision making process is some course of action. Thus DM is a function mapping information into courses of action. This process may be realized in a number of different ways, with or without human involvement. The course of action is then an input to the Execution function (E). This function

executes the courses of action as decided on by the decision maker and generates observable actions. These observables are physical actions which can be observed and measured by their interaction with the environment. These observables are not data or information but they are capable of being transformed into data. Thus E is a function which maps courses of action into observable actions. These observables are transformed into data by the Transformation function (T).

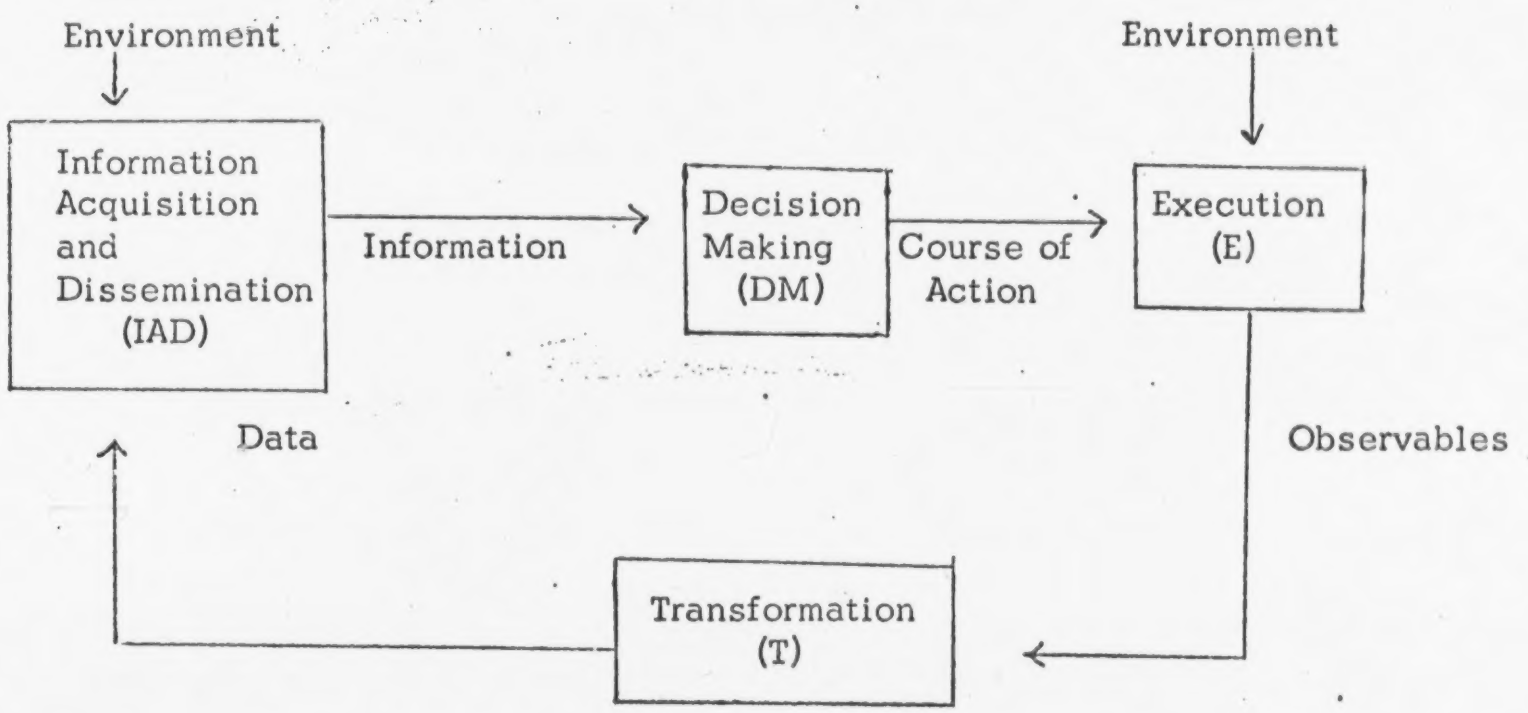

Figure 1 Generalized information system

How is the information selected from the data? This is the responsibility of the Information Acquisition and Dissemination function (IAD). Data are collected, organized, and stored by the IAD until such time as they may be useful to the DM. The IAD is frequently referred to as an "information system". Although it is of course a system, it is actually only a part of a much larger system. The IAD

collects data from within the system (the output of the T function) and from the external environment which is outside the system. The IAD also collects basic data such as references, tables, books, reports, and theories from other sources. The IAD then stores a data base. The IAD operates on this data base by restructuring, filtering, weighing, analyzing, ordering, relating, predicting, and displaying. The IAD disseminates data for use by the DM. Information then is that data used by the DM; so the roles of the IAD and DM must interface in determining what data are information.

We defined information as data of value in decision making. The smallest measurable change in the amount of information available to the DM is that amount which produces a measurable change in the observable actions. This smallest measurable amount of change in information is an important fundamental (although relative) quantity. It is relative depending on the situation under consideration, but it does give us a way of evaluating the effectiveness of the IAD and does define a measurable unit of information. For want of a better term, we call this an "informon".

This model has many applications and describes virtually all situations where information is used. It has been used to describe computer systems, management decision making, production control, science information, and education systems among other applications. We may use it as a means of relating the various applications of information science to one another. Librarianship we believe to be one of these applications.

In dealing with information science there is quite often a basic lack of differentiation between the science itself and its applications. An analogy might be the relationship between physics and the various branches of engineering. Physics is a true science dealing primarily with the study of energy in its various forms. Engineering is the application of that science to the solution of practical problems. Information science then may be said to be the study of information in its various forms. Library science, management science, and computer science may be considered to be some of the applications of information science. Although at this stage these terms are generally used with a lack of precision.

Computer and information science, like mathematics, is clearly very widely applicable. There is an increasing use of mathematics for describing methods in many other fields. Departments of psychology, business administration, and engineering, for example, frequently teach many courses in applied mathematics. The same thing may and probably will happen to information science. Computers and the methods of information handling can be applied in virtually every subject matter area and every department in a university.

Broad Curriculum Development

The utilization of information in different subject matter areas or in solving particular type problems has been developed largely in an ad hoc way. Methods and techniques have been developed. They, however, are specific to the situation and have little capability for generalization. When a new problem arises the existing methods are either unknown or generally unapplicable.

A large part of the present body of knowledge associated with information science deals mainly with these kinds of situations. It is our expectation that basic theories and conceptual relationships of general applicability will be obtained. A considerable research effort is devoted to this activity.

In organizing our Department of Computer and Information Science at The Ohio State University we have deliberately brought together a faculty, a number of whom have diverse backgrounds, so that collectively we can be familiar with the various ways information is used in different disciplines. In our curriculum we try to give the students an understanding of the theoretical foundations of information science as well as experience with various methods of dealing with information. This leads us to a very broad program which interfaces with a number of different departments in the University.

Our curriculum is built around a core program of courses from our Department and a small number of related courses chosen from other departments. The choice of which topics should be covered by other departments and which new courses should be offered within our own Department was a major practical problem in the development of our curriculum. Too many new programs in this field tend to be developed by putting together a list of existing courses in various departments and calling that an information science program. The students may indeed learn a number of practical ways of handling information, but these will be particular and specialized to the subject or type of information. Students in that kind of program will lack an understanding of the unifying basis of information science.

We have tried to develop a program which teaches the various techniques currently in use as well as to connect them in a unified fashion.

Accordingly, a major objective of the program is to provide students with a broad education in particular methods used in handling information and also to point them toward unifying theoretical concepts. The content, methods, and applicability of information science are of course constantly changing. The very rapid growth in the amount of knowledge and the increasing use of various and more sophisticated mechanized means of handling information have made it necessary for the information scientist constantly to increase the efficiency of his methods. We believe it is necessary to give our students a good fundamental background so they will be able to cope with the rapidly growing and changing field of information science.

This broad educational program, including practical experience with some of today's most advanced information processing systems, makes our graduates more employable, which is an important factor in today's market. This is naturally a most important point. Over the past few years we have averaged about 40 Master of Science graduates per year as well as a large number of Bachelor's degrees divided among our various programs. Our graduates by virtue of their broad and yet reasonably practical background have been hired for many different positions by a large number of different organizations. They work for example in places like Chemical Abstracts Service, Battelle Memorial Institute, International Business Machines, Control Data Corporation, Digital Equipment Corporation,

various systems companies, engineering organizations, and software organizations. Some are working on library type problems either directly in libraries or through organizations like the Ohio College Library Center or the Mechanized Information Center on The Ohio State University campus.

A broad education makes it possible for people to develop their interests in a flexible way so that they are able to move along with changes in technology. It has been abundantly clear over the last two decades that technically trained people must change their interests and capabilities rapidly. Very few of us who went to school more than five or ten years ago are doing what we were specifically educated to do in the university. It is the basic concepts that stand us in good stead over the years, not the specific training, although it is the specific training which assists in obtaing the first position. In other words, we hope that our students do not become technological dropouts. Conversations with many potential recruiters have re-inforced this feeling.

Another sound reason for a broad program should also be mentioned. We have found that many students enter our graduate program with a proconceived notion of what they plan to do -- largely because of a limited undergraduate background. After exposure to a number of different possible areas of study in information science they may change their interests entirely. For example, many students come into the program with a background in mathematics wishing to learn more about programming computers, since this is really the only background they have had in the field. They frequently find after the proper exposure that work for

example, in information storage and retrieval or on the computerized library circulation system, or information processing in biological systems is really quite interesting. This freedom to move easily from one area into another is perhaps the most important result of a broad program within a single department in a university.

The programs of the Department of Computer and Information Science at The Ohio State University emphasize education, research, and the professional practice and application of computer and information science. The Department offers four different undergraduate degrees (engineering, bachelor of arts, bachelor of science, and administrative science) and Master of Science (four separate options) and Ph.D. degrees. The research activities are a central part of the program and forms an integrated framework with the academic program.

Undergraduate Programs

Our undergraduate programs are built around a core program including courses* in computer programming, numerical methods, and information storage and retrieval. There are also a number of required advanced courses in mathematics and statistics. Undergraduate majors are also expected to develop a competence in some other area. Business management and engineering seem to be the most popular. Our undergraduate program although developed independently, roughly includes the ACM's suggested undergraduate program in computer science (4). By virture of its

*Ohio State is on the quarter system and all courses indicated are a quarter in length.

breadth naturally our program has many more options available than the ACM program and includes considerably more information science and broad applications of information science as we have indicated previously.

We have four separate undergraduate programs. Even though the Department of Computer and Information Science is organizationally housed in the College of Engineering, a student has considerable flexibility when choosing computer and information science as a major since the Department offers undergraduate degree programs in two other colleges as well as its own. There are four degree programs: a Bachelor of Science in the College of Engineering, a Bachelor of Science and a Bachelor of Arts in the College of Mathematics and Physical Sciences, and a Bachelor of Science in the College of Administrative Science. The particular program chosen depends on the student's interests and career objectives.

The major program for each of the four degrees consists of sequences of courses both in computer and information science and mathematics. The programs have calculus as the base in mathematics and, except for the program in the College of Administrative Science, each contain a required five course sequence in computer and information science. This sequence consists of three courses in digital computer programming, a course in numerical methods and one in information storage and retrieval. The major is completed with electives from both computer and information science and mathematics. Since these major programs are very similar, a student's educational background and interests and his career objectives will help him in choosing a particular program.

If a student is interested in obtaining both an education in computer and information science and mathematics, and a general education in engineering and science, then he will choose the program in the College of Engineering. Thus, he is able to develop a core of mathematics, basic science, and engineering science and at the same time specialize in computer and information science. He will also have the opportunity to elect a portion of his technical course work in order to develop his individual interests.

On the other hand, if a student is business oriented, then he will choose the degree program Bachelor of Science in Business Administration with a major in computer and information science. This program is designed to give an education both in computer and information science and mathematics and a general education in the administrative sciences. Its objective is not to make a specialist out of a student, but rather to enable him to recognize the opportunities to use the computer and information processes in his managerial activities, to know what to expect, and to know how to communicate effectively with computer and information specialists so that computerized projects will be properly handled from a technical, as well as managerial point of view.

The remaining two degree programs are in the College of Mathematics and Physical Sciences of the College of Arts and Sciences and hence, afford more of a liberal arts education. The Bachelor of Sciences program is designed for the student who is primarily interested in obtaining an education in computer and information science and mathematics while the Bachelor of Arts degree is for

one interested in both an education in computer and information science and mathematics and an education in some field related to computer and information science. Hence, with the former, a student obtains perhaps a somewhat more technical education in computer and information science while the latter provides for a somewhat more flexible major program. At the present time we have approximately 500 undergraduate majors in our various programs.

Curriculum Summary -- Undergraduate Programs

A recommended program leading to the degree Bachelor of Science in Computer and Information Science in the College of Engineering consists of 30 hours of computer and information science, including courses in digital computer programming, numerical mathematics, and information storage and retrieval, 35 hours of mathematics, 10 hours of statistics, 15 hours of physics, 11 hours of electrical engineering, 5 hours of biology, 10 hours of psychology, 8 hours of chemistry, and courses in industrial engineering.

A recommended program leading to the Degree of Bachelor of Science with a major in computer and information science in the College of Mathematics and Physical Science consists of 35 hours of computer and information science, including courses in digital computer programming, numerical mathematics, and information storage and retrieval, 35 hours of mathematics, 10 hours of statistics, 30 hours of natural sciences, and 15 hours of humanities, and 15 hours of social science.

A recommended program leading to the Degree of Bachelor of Arts with a major in computer and information science in the College of Mathematics and Physical Sciences differs from the Bachelor of Science program in that the arts program requires only 25 hours of mathematics, but includes the requirement for an advanced sequence of courses in any related field.

A recommended program leading to the Degree of Bachelor of Science in Business Administration with a major in computer and information science in the College of Administrative Science consists of 26 hours of computer and information science, including digital computer programming and information storage and retrieval, 25 hours of mathematics, 10 hours of statistics, 10 hours of accounting, 33 hours of business organization, 22 hours of economics, and 5 hours of geography.

Graduate Program

The first year of the graduate program is built around a core while includes courses on digital computer programming, digital computer organization, human performance, fundamentals of information storage and retrieval, numerical analysis, and concepts of computer and information science. All graduate students are required to take courses in this core. Our graduate program contains four main areas or options -- information systems, computer systems, numerical analysis, and a theoretical option. The student specializing in information systems for example, then will select additional courses from: Modern Methods of Information Storage and Retrieval, Modeling of Information Systems, Document Handling

Information Systems, Analysis and Synthesis of Information Systems, Theory of Indexing, Language Processing for Information Storage and Retrieval, Management Information Systems, File Structures, and Theory of Information Retrieval. Besides these regularly scheduled courses we also offer a number of special courses on a timely basis depending on particular student and faculty interests. [In Columbus, Ohio, there are a number of organizations concerned with information processing. Some of these are Chemical Abstracts Service, Battelle Memorial Institute, Western Electric Corporation, Bell Laboratories, North American Rockwell Corporation, and a number of others. Scientists in these organizations occassionally teach courses for us or participate in graduate level seminars. The existence of these organizations and their personnel is an important resource of which we attempt to take advantage.]

This is an existing graduate program with most of the courses taught on a regular basis. Currently there are about 70 courses offered by the Department, 15 of which are largely undergraduate with the remainder being upper level undergraduate and graduate courses. The Department also teaches separate sections of two advanced psychology courses, one of which is a requirement of the graduate program, and the other an elective. In addition to these courses there are over two hundred courses offered by a variety of departments of the University which are of interest to our graduate students who are encouraged to take these courses. At the present time we have about 75 graduate students in our Department at various levels. Approximately one quarter of these are in the information systems area. We expect to graduate 14 Ph.D. candidates this year.

Programs at the graduate level have been developed, in some cases jointly with other departments, in the following 14 areas:

1. General theory of information.
2. Information storage and retrieval.
3. Theory of automata, finite state machines, and computability.
4. Artificial intelligence, self-organizing and adaptive systems.
5. Pattern recognition.
6. Computer programming, including systems programming languages and translators.
7. Theory, design, and application of artificial programming languages and translators.
8. Digital computer organization and functional design.
9. Numerical analysis and mathematical programming.
10. Man-machine interaction and systems, particularly in a conceptual sense.
11. Computational and mechanical linguistics, semantic analysis, machine translation of natural languages.
12. Management information, including logistics information systems, theory of organization, information as a resource.
13. Information processing, transmission, and communication in biological systems.
14. Social, economic, and psychological aspects of information production and processing.

Courses taught by the Department are listed below:

Computer Programming and Data Processing I
Digital Computer Programming I
Group Studies
Computer Programming and Data Processing II
Fundamental Concepts of Computer and Information Science
Survey of Computer and Information Science for High School Teachers
Survey of Numerical Methods
Introduction to Computing in the Humanities

Digital Computer Programming II
Digital Computer Programming for High School Teachers
Numerical Analysis for High School Teachers
Introduction to Information Storage and Retrieval
Survey of Programming Languages
Human Performance
Numerical Analysis
Computer Systems Programming I
Numerical Linear Algebra
Linear Optimization Techniques in Information Processing
Advanced Computer Programming
Modeling of Information Systems
Digital Computer Organization
Data Structures
Individual Studies
Introduction to Computer and Information Science
Information Theory in Behavioral Science
Man-Machine Interface
Introduction to Linguistic Analysis
Theory of Automata I
Theory of Automata II
Theory of Automata III
Basic Concepts in Artificial Intelligence
Statistical Methods in Pattern Recognition
Computer Systems Programming II
Numerical Solution or Ordinary Differential Equations
Advanced Numerical Analysis
Modern Methods of Information Storage and Retrieval
Fundamentals of Document-Handling Information Systems
Techniques for Simulation of Information Systems
Theory of Indexing
Language Processing for Information Storage and Retrieval
Programming Languages
Compiler Design and Implementation
Selected Topics in the Mathematics of Information Handling I
Theory of Management Information Systems
Advanced Computer Organization
File Structures
Intermediate Studies in Computer and Information Science
Interdepartmental Seminar
Information Theory in Physical Science
Cellular Automata and Models of Complex Systems
Computer and Information Science Research Methods

Human Performance Theory
Computational Linguistics
Special Topics in Pattern Recognition
Numerical Solution of Partial Differential Equations
Theory of Information Retrieval I
Theory of Information Retrieval II
Design and Analysis of Information Systems Simulations
Formal Languages
Seminar on Socio-Psychological Aspects of the Information Sciences
Theory of Computability
Advanced Studies in Computer and Information Science
Advanced Seminar in Computer and Information Science
Interdepartmental Seminar
Research

Research

Since the body of knowledge associated with information science is rapidly growing, we naturally feel it is important for our Department to be actively involved in research. Our model of a generalized information system has grown out of this research program. We feel that students learning about information science should frequently also be involved in this research. Naturally, those students proceeding to the doctorate must be involved in research.

Among the research activities being pursued are the following tasks, classified into eight broad areas of computer and information science.

Information Storage and Retrieval with the following specific tasks: indexing theory, indexing and re-indexing simulation research; automatic indexing; chemical information processing (including, applications of graph theory; identification of cycles in chemical structures; chemical structural information storage and retrieval; and chemical notation systems); automatic abstracting; automated search systems; on-line retrieval systems; parallel processing; and, CRT editing research capability

Human Information Processing with the following specific tasks: information processing models; response execution; complex information processing; memory functions; information and decision making; transfer processes in memory; and, discrete stochastic processes for learning.

Information Analysis with the following specific tasks: generalized information systems; management information systems; minimum redundancy coding; information classification theory; stochastic optimization; optimum data allocation; error-correcting codes; optimal information structure; and, advanced computer design.

Linguistic Analysis with the following specific tasks: generative lexicology; research in communication by spoken language; formal properties of grammatical theories; speech recognition and synthesis; formal language theory and automata theory; computer simulation of language learning; automatic language processing; and, relational languages.

Artificial Intelligence with the following specific tasks: pattern recognition by retina-like devices; pattern and algorithms (including, universal algebras, groupoids, pascaliation patterns, monomial strings); decision theory for pattern recognition; logic design by pseudo-Boolean programming; predictive pattern recognition strategies; learning automata theory; and, developmental problem solving.

Information Processes in Physical, Biological and Social Systems with the following specific tasks: molecular cybernetics and biophysics; optic nerve information; visual information used in determining behavior; visual psychophysics; attribute structure and attitudes; and, informational and organizational concepts in science.

Mathematical and Numerical Techniques with the following specific tasks: investigation of round-off errors in hybrid multistep methods; pseudo-random number generators; comparison of methods for the solution of ordinary differential equations; the solution of stiff differential equations; and methods for finding eigenvectors and eigenvalues of matrices.

Programming Languages and Systems with the following specific tasks: algorithms for parallel compilation of statements in programming languages; graph models for parallel computations; improved translator writing systems for programming languages such as XPL, LISP, and PL360 on the IBM System 360; and development of a PL/1 compiler for the PDP-10.

All of these research activities are being performed under the guidance of qualified faculty in Computer and Information Science and other related areas, and with the benefit of computational facilities surpassing those of most other Universities.

In the process of education there is a transfer of information. The relationship between teacher and student shows many of the aspects of a management system. We have been interested in ways in which the methods of information science apply to the design of curricula and the management of educational systems. This brings us around full circle. The study of educational methods is appropriate to information science and accordingly the problem of educating information scientists is itself a problem in information science.

Some Information Processing Activities at The Ohio State University

The Ohio State University has a number of ongoing operational activities in the forefront of information science, particularly in the area of library automation. Certainly in these areas Ohio State is one of the leading universities in the world.

Some of the more interesting activities currently on the campus are listed below:

Computer Art
Professor of Art: Charles A. Csuri

User oriented computer programs to create art film and animated illustrations. In this computer environment the artist draws images on the cathode ray tube and computer programs allow him to instantaneously "fly", "walk", or "model" drawings through two and three dimensional space, i.e., a helicopter that "flies" on the screen, a turtle that walks or swims through three dimensional space, and the artist has independent control over the movement of the turtle's head, the tail, and each of the four legs in real-time. These programs also include a solution to the real-time hidden line problem.

Computer Assisted Instruction
Coordinator: G. Ronald Christopher

Computer Assisted Instruction exists to provide individualized instruction to all disciplines to students in this institution. At present 34 courses or segments thereof are on the system, 18 are operational.

The system is available to the students seven days a week at each of 18 student CAI terminals located in geographically dispersed, readily accessible student areas. Developmental work in other applications is presently under way.

Division of Computing Services of Medical Research and Education
Director: Edward J. Nime

This Division supports and develops instructional use of computers. Assists College personnel in utilizing computers for information storage and retrieval. Gives assistance in developing programs. Consults with medical researchers on the utilization of computers in their products. The Division is teaching and developing courses in electronic data processing and systems analysis and design.

ERIC Center for Science and Mathematics Education
Director: Robert Howe

This Center is devoted to the retrieval and dissemination of important information related to science education, mathematics education, and more recently to environmental education.

ERIC Center for Vocational and Technical Education
Director: Robert Taylor

The ERIC Clearing House for Vocational and Technical Education acquires, selects, abstracts, indexes, stores, retrieves, analyzes, and disseminates research and related information on vocational and technical education in such related fields as manpower, economics, industrial arts, education, occupational psychology and occupational sociology.

Health Center Library
Director: Miss JoAnn Johnson

Serves the Colleges of Dentistry, Medicine and Optometry besides traditional library services. The computerized searching services include AIM-TWX (Abridged Index Medicus-), C-BAC (Chemical and Biological Activities), and a SUNY Biomedical terminal. Also included are fully automated stacks, sophisticated audio-visual resources, CAI modules, etc.

Instruction and Research Computer Center
Director: Roy F. Reeves

Supplies the computer services necessary for instruction in computing, including the mechanics of programming as well as computer language

training, the use of the computer to solve problems related to computing instruction, and those activities which use the computer for sponsored or unsponsored research. The Center uses primarily an IBM 370/165 computer.

Learning Resources Computer Center
Director: J. C. Notestine

Deals with activities involving instructional support for the University, especially as they relate to Libraries, information retrieval, testing evaluation, and computer-assisted instruction.

Library Circulation System
Director: Hugh C. Atkinson

This is a computer based on-line circulation system. Utilizing input and output units in the main and branch libraries, the new system is designed to save students time and facilitate use of the University's network of libraries. By phoning the library, a student can find out immediately if a book is available and if so have it reserved for pickup.

Mechanized Information Center
Director: Gerald Lazorick

The Mechanized Information Center (MIC), administered within the Public Services Division of The Ohio State University Libraries, is in the initial stages of a four year development period which will see the introduction of broad computer based information services to the undergraduate students, graduate students, faculty and researchers of the University. This is a joint project with the Department of Computer and Information Science.

MEDLARS (Medical Literature Analysis and Retrieval System)
Senior Medical Search Analyst: Miss Laura K. Osborn

Computer based system in operation at the National Library of Medicine. The system has been designed to achieve rapid bibliographical access to biomedical journal information. It became operational January 1964 with the publication of the first computer produced issue of Index Medicus. Includes a comprehensive subject index to articles from approximately 2300 of the world's biomedical journals. MEDLARS is designed to be processed in a batch mode. A terminal is available in the Health Center Library.

Ohio College Library Center.
Director: Frederick G. Kilgour

The Ohio College Library Center is a not-for-profit corporation chartered by the State of Ohio to make the library resources of all Ohio academic

libraries available to each other. The Center operates computerized systems to assist member Ohio Colleges and Universities provide a faster, more efficient search and retrieval system of library books and journals, and carries out research, development and implementation of such systems. An off-line catalog production system is now in operation. The central computer is a XDS Sigma 5 with disc packs for secondary memory.

Pilot Medical School
Project Supervisor: Robert L. Folk

Students in The Ohio State University College of Medicine's Pilot School have been freed from the restrictions of traditional education with the aid of advanced computer software and an on-line, real time terminal network. Instead of attending lectures and taking exams, these students pursue their medical studies under an entirely new learning model. This model, centered around independent study, allows the student to progress at his own rate, with individualized instruction. The Coursewriter III software package along with local modifications, enables the Pilot School to allow students to progress in such an unrestricted manner. This program is the first of its kind in the country.

Summary

In summary, we believe a curriculum in information science should be a broad one built on a fundamental understanding of the field. Many applications should be available to the students both academically and in practice. It is important that technology be incorporated into the program, particularly with regard to the use and organization of digital computers. A strong research component should be included.

The Department of Computer and Information Science has developed academic programs leading to the bachelor's degree, to the master of science degree and to the Ph.D. degree. The bachelor's degree may be obtained in Arts and Sciences, Engineering, or Administrative Sciences. The Master's degree may be

obtained in one of four options: theoretical, computer systems, information systems, or numerical analysis.

The academic and research programs include fourteen different areas of interest. There are currently about 70 quarter length courses offered on a regular basis. There are about 175 graduate and 500 undergraduate majors now enrolled.

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INFORMATION SCIENCE UNIVERSITY PROGRAM, DEVELOPED THROUGH A DIGESTED PROJECTION FROM EUROPEAN AND U.S. TRENDS

BY

K. SAMUELSON

Information Processing-ADP

Royal Institute of Technology and Stockholm University

INTRODUCTION

The following presentation is a description of the step by step development and implementation of a curriculum and program in information science, for all universities in one of the Scandinavian countries, namely Sweden. The development started in 1964, and the gradual improvement of shorter courses had led to the final implementation of a full-year university program at the senior graduate level; that is, last year of a Masters Degree or Post Graduate to those who have an earlier university degree.

The program is truly interdisciplinary and open to graduate students and professionals with a background in many different fields: For example, engineering, management, science, medicine, agriculture, law, forestry, geosciences, libraries, archives, publishing or mass communication and industrial psychology.

BACKGROUND

In 1964 to 1965 the first pilot course in "Transfer of Scientific Information" was held at the Royal Institute of Technology (RIT). That course was intended as a one-year, part-time education for people having an academic degree and already working within or planning to enter the field

of information and documentation. Since then, half a dozen similar experimental courses have been put together and launched by RIT or bodies such as the professional society (TLS) which is the Swedish counterpart to ASIS, the employment organization (AMS), one extracurricular course organizer (IVAK), and a research sponsor (SINFDOK).

Also at the RIT and Stockholm University jointly, yearly courses have been given since 1966, lectured by the author and termed "Informatology and Information Systems". This topic has been a third year, concentrated course for advanced students of "Information Processing especially Administrative Data Processing (ADP)". Identical courses have later come into existence at the Universities of Gothenburg, Lund and Uppsala as a regular training.

Between 1966 and 1969 the author worked as an expert member of an overall planning committee for future education in information science, as well as archives and libraries. The committee studied the existing training schemes of most of the countries concerned. Different committee members officially visited the following countries: Denmark, Holland, England, Norway, Finland. Individual visits were also made to other countries and international conferences. The author studied most of the schemes for information science available then in the U.S. He met with the representatives of, and/or visited, fifteen universities: Columbia and City University of New York, U.C.L.A., U.S.C., U.C. at Berkeley, Stanford University, Ohio State University, Case Western Reserve University, Georgia Institute of Technology, Florida State University, Florida Atlantic University, Massachusetts Institute of Technology, University of Maryland, Syracuse University, and SUNY at Buffalo.

At the end of 1969, the committee presented a plan and made recommendations on the course of action. One of the issues was establishing "Information Science" (Informatik ≈ Informatics) as a separate science subject in all Universities and with one consistent educational program. The name INFORMatik was chosen for a number of reasons. One of them was to maintain empathy, whereas DOCU had become a "four letter word" that is somewhat passé. The committee also recommended the building of one or two separate library schools, while archival training would

remain as an extension of already existing activities. The information science education would be physically distinguished from the Library school and performed in closer relationship to "Information Processing-ADP". The information science program has now, in the year of 1971, come into existence at the RIT and Stockholm University combined. Step by step the identical program may be extended to the other universities. The information science curriculum and "modus operandi" is based on six years' experience of the above mentioned course in "Informatology and Information Systems".

ESSENTIAL OUTLINE OF THE PROGRAM

Before listing the details we shall survey the basic philosophy and major issues of this specific university program in information science. A student can enter the program having acquired any one among a variety of university backgrounds, including business school and law school, as well as library or engineering school. Dentists, M.D.'s, lawyers, psychologists, military officers or veterinarians are welcome. Those who do not have an earlier degree get a Masters with last year specialization in information science. The only math knowledge needed is at the highschool or junior college level.

The full-year program starts with a three months prerequisite course module of introductory non-numerical information processing and administrative data processing. Having fulfilled this course the students are allowed to complete the remaining eight months including a thesis. The thesis is done as a sort of junior consultant work with an outside organization, industry, corporate business, library, hospital, patent firm, publisher or information center. The thesis work is implemented during 2-3 months as a pilot project, design module or test phase in fulfillment of an internship or on-the-job practice within the respective outside body, at the end of the full year.

In general, the program is slanted toward the system analysis and cybernetics approach. The philosophy is to teach methodology and management in non-mathematical terms rather than techniques. The graduates would become managers capable of decision making, crude design, synthesis, and evaluation of information systems, as a protection

against technical gadgetry or point rationalization. Furthermore, the graduates should not become file-clerks or lifetime catalogers. The program does not train circuit designers, programmers or hardware developers, but rather professionals for brainware and know-how.

The curriculum contents is not like yesterdays, centered around just the storage and retrieval of documents. Instead, an emphasis is put on the transfer, communication and overall utilization of information using todays current multimedia, networks, teleprocessing, videophones as a gross part of societal activities such as:

international communications
trade and marketing information
industrial catalogs
legal documents
medical records
engineering drawings
construction maps
patent activities
insurance records
film archives
book collections
educational material
videofiled TV programs
investment and finance news
police dossiers
publishing
social records
newspaper clippings, etc.

After graduation, the information scientist (Informatiker ≈ Informatician) would be able to make sound assessments to avoid the hardselling of electronic gadgets. He should also be capable of judgment on issues like the creeping bureaucratic privacy invasion and paper pollution by forms, inquiries about personal data, or "ad lib" declarations claimed "necessary for statistics" or this or that haphazard reason.

The fullfledged information scientist would be trained for the executive level to become a manager, director or vice president. He would hold positions and titles such as:

vice president, information
director of information
information manager
information center executive
information systems analyst
library systems analyst
head of information science staff
chief, information science
information liaison
scientific attaché

In his career the information scientist would advance through some of the above listed professional functions.

CONTENTS OF THE PROGRAM

Educational Objectives:

-- To make the students acquainted with basic theories, methods, communication and organizing within information science.

-- To transfer knowledge about the design and synthesis of information systems having large permanent storage files, and the practical use of these within a number of application areas and information activities.

-- To create ability for each student to individually and critically suggest solutions to a specific practical information science task within a particular application area.

Course Module I. Introductory Information Processing (Prerequisite).

-- Introductory non-numerical information processing and administrative data processing. BASIC programming in dialog mode.

-- Business data processing and COBOL programming.

-- Information systems algebra, decision theory and introductory operations research.

Course Module II. Principles, Methods and Applications of information science.

-- General orientation about the meaning of information science, kinds of information, ways of transfer and communication.

-- Principles for storing information and documents.

-- Content analysis and concept notation for information handling in practical work. Classification, codes, notation, literation thesaurus structures, referencing, extraction, indexing, citation, cataloging, editing, formating, systemization and the use of computers for these functions.

-- Search, retrieval (IR) and selective dissemination of information (SDI).

-- Design of search strategies, formulations and profiles.

-- Information material, reference services, sources, data-bases, fact and information-banks, files and document storage. Orientation about libraries and archives.

-- Scientific-technical terminology, nomenclature authorship, editing, journalism and report writing.

-- Reprography, copying processes, computer techniques for handling documents and microforms.

-- Automated information systems, electronic equipment, mechanized and automatic presentation including pictorial, graphic, textual and data displays.

-- Construction, design and synthesis of information systems. Evaluation criteria and economics of information and documentation.

Course Module III. Theoretical and scientific basis of information science.

-- Cybernetics 1: adaptive systems.
Cybernetics 2: evolving systems, growth and ecosystems.

-- Theories about intelligence activities, diagnostic processes, intellect, brain functions and thought processes.

-- Innovation theory, processes for inventions, creativity, problem solving and reasoning.

-- Decision processes and executive decision making in active productions. Human information processing and man as an operator and link in automated man/machine systems for information science.

-- The engineering and ergonomic side of information systems where man and machine interact. Occupational health aspects on the information scientist's work and the information user's channel capacity and perceptive ability.

-- Transfer of information for scientific and technical use. Information value and its dependence of fast communication and "expensive" transfer.

-- Information and data transmission. Automated aids for the transfer of optimal information in pictures, writing and audio.

-- Information channels, diffusion routes and flow patterns in context to information.

-- Non-stored information, audio-visual communication, conferences and non-formal human communication.

-- Knowledge about multimedia research and existing physical media for information. Possible use of fragmentary and non-formalized information in making conclusions and finding problem solutions.

Course Module IV. Organization and administration within information science.

-- Organization, applications and methods in operative handling of information and document materials for science, technology, industry and other societal functions.

-- Formation and function of organizations where information digestion exists at "high frequency". Information and reporting systems in different organizations, corporate business, industries, hospitals, libraries, archives, etc.

-- Different types and uses of scientific information and specialized sources such as patent collections, personnel files, stored graphs and drawings, etc.

-- Administrative cybernetics in organizations and society and the indications for representation, construct, structuring and organizing of information.

-- Goal formulation and objectives for control and management of documentation and information systems.

-- Administration of scientific and technical communication, information centers and decentralization. Control and administration of research and development and their coupling to operational information systems with regard to long-range planning.

-- Industrial documentation and management information systems. Tracing and utilization of innovations by using computers to create idea banks for futuristics. Strategic value of information.

-- National and international organizations for information science. Integrated information systems, documentation and automated information networks. Compatibility, convertibility and reliability.

-- Legal matters, privacy and integrity when using information or documents and the sequels for users and sources.

-- International cooperation in short-run, mid-term and long-range planning, economics and further developments of different application areas for information science including automated documentation.

Course Module V. Thesis and design implementation or experimental testing of a specific information science task within a practical environment or real-world situation.

CONCLUSIONS

The information science university program and curriculum described above is aimed at giving a substantial, thorough and adequate academic training for interdisciplinary applicability. Those students which have fulfilled the program requirements should be able to work ever after as professional information scientists in industry and society. They could also continue working towards a doctorate in information science or another field depending on their basic training. Several of those graduates would no doubt be absorbed as academic teachers and lecturers, which are presently in demand for the fairly young interdisciplinary field named information science.

CURRICULUM DEVELOPMENT FOR INFORMATION SCIENCE: A SYSTEMS APPROACH FOR A NATIONAL EFFORT

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by

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To talk of curriculum development for information science to a group such as this is to undertake a project with very far-reaching goals. It calls for a breadth of understanding and technical command of the problems involved which go far beyond our individual capabilities and far beyond any existing curriculum developments at any particular university. We all recognize that there are at least four "orientations" to information science courses (Borko, 1970) and at least seven core courses (Belzer, 1971),and six disciplines from which information science draws (Belzer, 1971). But we have not yet approached curriculum development from anything but the institutional approach -- in other words, what fits our local faculty's view of what information science is or needs to be and what can be taught at our school. To the best of my knowledge there has been no consortium established of library schools, information science programs, and computer science departments to effectively plan on a national scale what we are doing, why we are doing it, and what our end product is. To talk of accreditation or professional achievements without such an effort, is, in my opinion, to put the cart before the horse. Jack Belzer, after making the survey of courses in 45 schools, had this to say about the situation: "The diversity

presently displayed in many programs is not likely to produce an identifiable information scientist or information specialist." Can we continue to tolerate such ambiguity or should we make an effort to bring this house called "information science" to order? Can schools teaching the basic content of information science (in separate or integrated courses) agree on the common knowledge of information science? Can an effort be made to single out those institutions with specialization programs in the field so that students can determine which schools match their career goals? Can we try to identify faculty who are experts and specialists in the field? Will we need different courses or curricula for students with different aptitudes or career objectives? Will different teaching approaches and educational materials be needed if curriculum objectives range from academic knowledge and skills to career or vocational skills and aptitudes? Can our concerns for information science education be limited to graduate courses leading to master's or doctor's degrees? Where does a program for continuing education in information science belong?

If you are intrigued by any or all of the above questions, than you are probably willing to get involved in a project of curriculum development on the national scale, and to work on the task of examining and defining the goals and values of information science education in order to maintain a rational basis for detailed academic planning. My message is directed to those of you intrigued by the possibility of national planning for IS education.

But before we embark on such an escapade we need to pause and reflect on a lesson from history, one incident from our own field, one from the field of education.

How many remember the Symposium on Education for Information in 1965 at Airlie House (Heilprin, 1965)? What came of that effort to examine and clarify education for information science? The following recommendations come from the report of one of the working groups at that 1965 symposium:

> "Recommendations: The group offered the following recommendations for consideration by ADI, as well as teachers and administrators of educational programs:
>
> 1. A watchdog committee for Education in Information Science, consisting of three to five rotating members, should be constituted. Members would report to the field the areas of interaction between the sciences and engineering as well as trends and developments relevant to training and research in information science. This committee would work toward identifying areas of knowledge thought to be relevant or necessary for personnel in this field.
> 2. There is a need to define and describe the core subjects in this area, both on the theoretical and practical levels. An effort must be made to maintain a dialogue between these two areas. To do so without any real common language will

be difficult. This is a major task of the next two years.

3. There is a need for a "laboratory library" environment for students, teachers, and research workers in this field, as now exists in education laboratory schools and in the physical and biomedical laboratories.
4. There is a need for "anticipatory updating" of personnel, teachers, and administrators--courses or institutes where critical review, trend reports, and background papers are presented.
5. We need to move closer to the specification of the intended behavioral outcomes of our teaching programs in this field. To describe curricula without this statement first is pointless.
6. We need to make a distinction between esoteric technology and basic research in this field. The "use" and "mention" problem has its counterpart in information science teaching. The complete system must be used as well as mentioned as an instrument of teaching.
7. We need to establish pedagogical archives containing course syllabi, final exams, course bibliographies, the best term papers, vita of faculty, job descriptions of graduates, etc. This archive could form a basis for comparison and redesign of curricula.
8. There is a need to distinguish between retaining a

person already in the field and training a person just out of college.

9. We must continue the dialogue between theoreticians and empiricists.
10. Where do we get teachers in this field? Are they Ph.D.'s or experienced people from industry? How can we attract teachers?
11. There is a need to determine criteria for evaluating good teaching in this field.
12. An interdiscipliniary approach to structuring the information sciences is needed.
13. Training programs for the field should reflect the team approach which is necessary when in the field, as is done in the sciences.
14. We need to study and teach the historical evolution of the field.
15. There is a need to relate recruitment to the kinds of programs presented. Schools may serve this function and this must be recognized as a basis for the development of the field as a profession."

(Heilprin, et. al., p. 173)

I quoted this at length because I want to emphasize how easy it is to isolate issues and make recommendations when we are brought together as we are for this conference, but also how easy it is not to get involved in any action plans to solve those problems. Maybe we can criticize the planners of the 1965 symposium because they brought together too diverse a group to work effec-

tively after the meeting was over. That can't be a sufficient reason for our inactivity if we do nothing after this meeting because we seem to represent the right mix of information science educators this time and the professional societies engaged in monitoring IS Education are well represented. Surely we can initiate a working group for a national IS curriculum development project if we can agree it needs to be done.

How many have heard of the Physical Science Study Committee (PSSC) or the Chemistry Education Materials Study (CHEM Study) or the Biological Sciences Curriculum Study (BSCS)? All of these projects and several others were financed through NSF funds and used developmental processes in preparing curriculum materials. We can learn a great deal from these efforts in the late 1950's and 1960's by analyzing the differences in approach taken by various projects and reading about their successes and failures. Luckily for us a book has been published entitled Developmental Curriculum Projects: Decision Points and Processes (Grobman, 1970) which covers everything from the financial and organizational constraints of these projects to the development of aims and purposes, from problems in diffusion to aspects of evaluation. Dr. Grobman identifies the critical facets of the work of developmental curriculum projects and what seem to be some promising approaches. Although she does not include in her book a prescribed set of procedures to follow for new projects, it is a useful reference tool for any group engaged in such an effort.

We know a lot more now than we did in 1965 about information

science and about curriculum-development projects. We should be able to take advantage of our increased knowledge. Looking beyond local institutional goals, perhaps the time is ripe for a national effort. The members of the ALA/ISAD-LED Interdivisional Committee on Education for Information Science and the ASIS/ Education Committee together could probably form a nucleus for a steering committee. The formal recommendations or resolutions of this symposium could add impetus to such a cooperative endeavor.

For the purposes of this discussion and to focus our attention on one cooperative endeavor in the educational field (instead of enumerating again fifteen recommendations as was done at Airlie in 1965), I would like to propose the following resolution be formally adopted by this group:

> ASIS and ALA, through their respective committees on education for information science, should endorse and support a Developmental Curriculum Project for Information Science. This project's objectives would be to produce some new kind of curriculum by means of a group effort, using experimental tryouts of preliminary efforts and collecting feedback from such tryouts to be used for the improvement of the curriculum prior to its release (and endorsement by ASIS and ALA) for general distribution.

Curriculum in the above resolution includes any activities relevant to student learnings, e.g., classroom textbooks and guides for instructors, laboratory experiences, preparation for teachers, etc.

Group effort implies an extra-institutional approach to education and curriculum development and a systems approach to education. Figure 1 shows the relationships among several groups in the Developmental Economic Education Program (DEEP). The group effort for IS Development Curriculum Project would not be as involved.

"Experimental tryouts" implies a systems approach (Fig. 2) which can be translated for purposes of instructional development (Fig. 3).

Release implies evaluation and ultimate production of some products which would be available for use wherever the subject is taught. In this day of mixed media, the materials prepared could be anything from materials for independent study or student-teacher interaction, to large group instruction, live or via television.

If some effort were to get underway to initiate a Developmental Curriculum Project for Information Science, we should understand the scope of the tasks involved.

1. This would be an effort which would stretch over several years and require funding beyond the ability of ASIS and ALA.
2. We would have to establish who had responsibility for policymaking and for decision making, who would be involved in preparing materials, how they would be tested, evaluated, and released.
3. We would have to establish our primary educational goals and recognize our differing orientations

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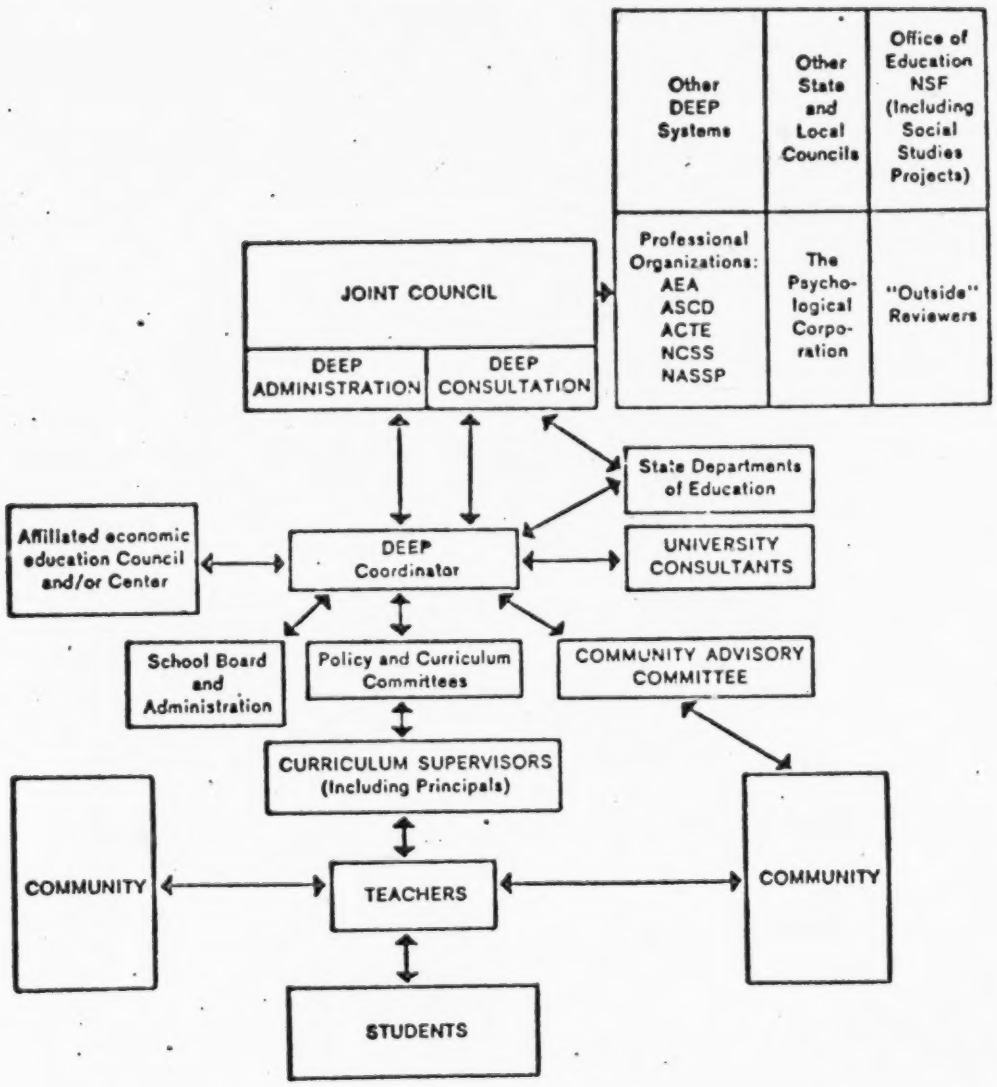
Figure 1 for Atherton paper
(from Grobman, p. 18)

Illustration 1

THE STRUCTURE OF DEEP IN A SCHOOL SYSTEM

This diagram shows the relationships among each of the parts which make up the structure of DEEP.



From: John E. Maher, Stowell Symmes, and William D. Green, Chap. 2, The results of DEEP, In Joint Council on Economic Education, DEEP 1969. New York: Joint Council on Economic Education, 1969.

Figure 2– The Systems Approach

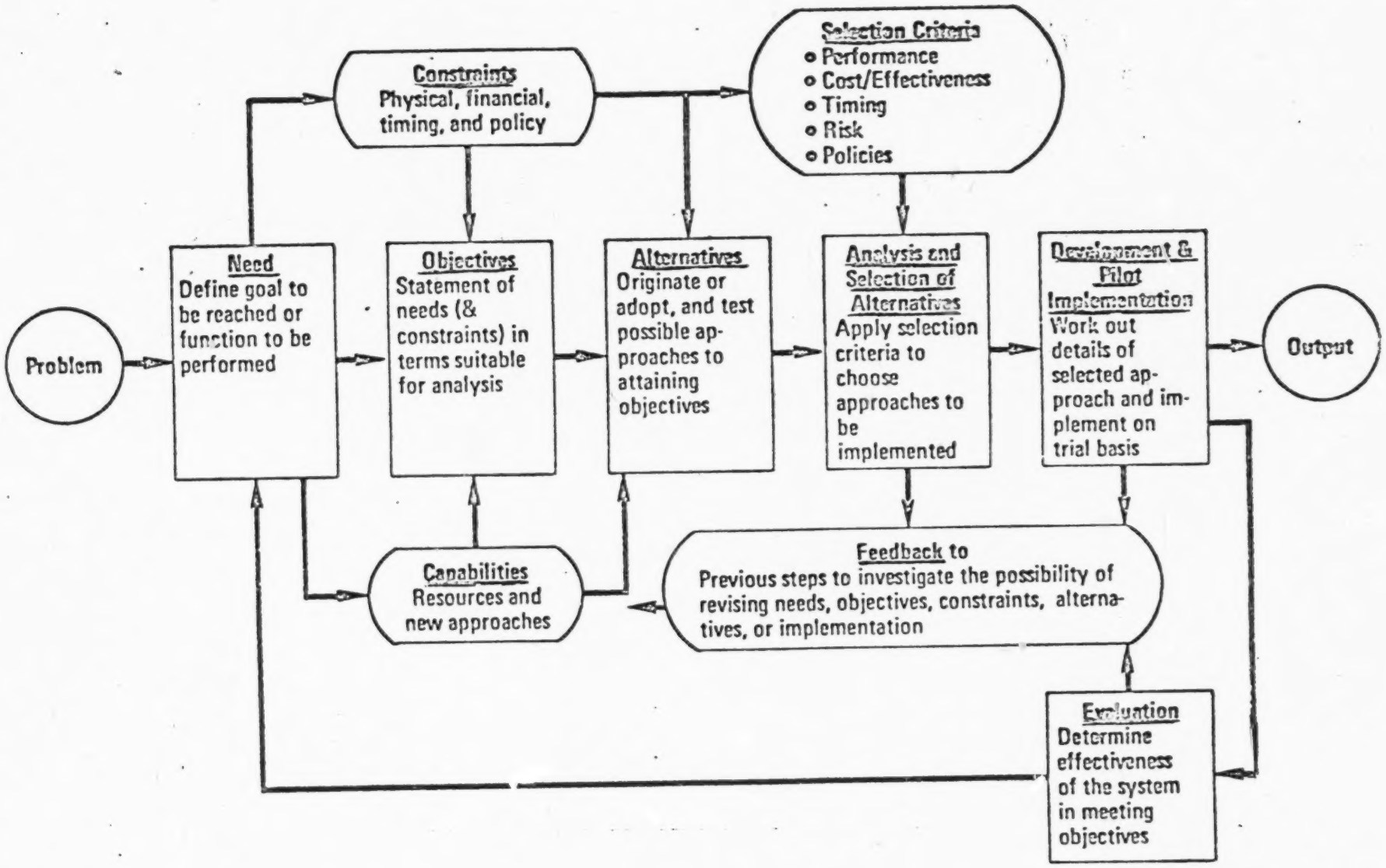
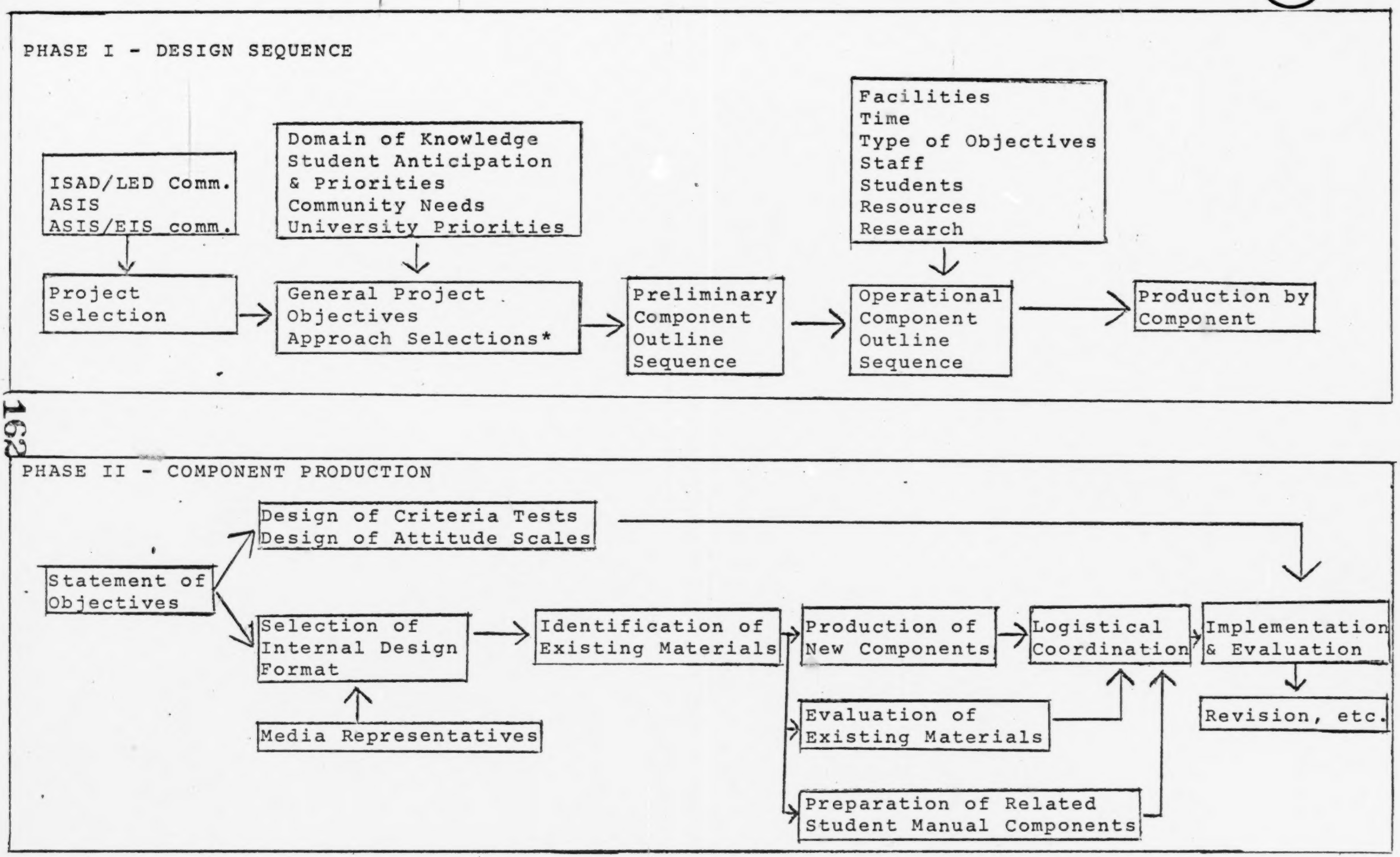

Selection Criteria
o Performance
o Cost/Effectiveness
o Timing
o Risk
o Policies
Constraints
Physical, financial, timing, and policy
Problem
Need
Define goal to be reached or function to be performed
Objectives
Statement of needs (& constraints) in terms suitable for analysis
Alternatives
Originate or adopt, and test possible approaches to attaining objectives
Analysis and Selection of Alternatives
Apply selection criteria to choose approaches to be implemented
Development & Pilot Implementation
Work out details of selected approach and implement on trial basis
Output
Capabilities
Resources and new approaches
Feedback to
Previous steps to investigate the possibility of revising needs, objectives, constraints, alternatives, or implementation
Evaluation
Determine effectiveness of the system in meeting objectives

Figure 3. PROCESS FOR INSTRUCTIONAL DEVELOPMENT



from: Robert M. Diamond
Center for Instructional
Development, Syracuse Univ.

(Borko, 1970) and the differing career goals of our students. To sort out these goals we could hold regional conferences similar to those held for computer oriented curricula in business schools (McKenney and Tonge, 1971).

4. Regarding learning outcomes, we should identify our primary focus. Dr. Grobman (1970) explains the Bloom, Krathwohl, and Simpson "levels in the cognitive, affective, and psychom[redacted] domains" (p. 89-96, 233-243). Discussions among information science teachers and educators would help us specify our goals in behavioral terms.
5. We would have to deliveate how far the project would go along the research - development - application continuum: exploratory research, fundamental development, specific development, design and improving, training and follow-through (Glaser, 1969).
6. We would have to recognize and learn to cope with the complexity of change -- as the developmental curriculum project goes through the formative period and as we begin the diffusion process in the field of Education for Information Science.
7. We need to recognize that different types of change require different degrees of effort. Working as we would be with adults (students and teachers alike), we must recognize that basic behavior changes -- changes in the way individuals think and act -- may

be very difficult.

Given such a task as the above as our next order of business, we can see that the reports of Heilprin, Borko, and Belzer have brought us to the launch pad. Are we mature enough as a field to go from here? Is there a Saul Amarel in the group who can give us a conceptual framework for curriculum planning? (Fig. 4-5) (Amarel (1971) did a beautiful job for computer science, a "sister discipline.") Is there a Dr. Green in the house (in Management of Information and Knowledge, p. 107) who can make us think of educational policy planning as going beyond the formal educational system. Dr. Green says "what is needed is a view of the educating system of American society as opposed to its educational system, and that educating system will have to include the places where work is done." He sees the time when the attainment of education would be distributed not over longer consecutive periods in the life of an individual, but over shorter spans of time in the entire life cycle of an individual. If this will be true, then what lies ahead in the field of education for information science? Is the past and present or the future fiction -- to ad lib from David Hays' provocative opening address at this ASIS meeting?

Editorial Note: The resolution proposed in this paper was adopted by the Symposium participants, but not in Mrs. Atherton's original wording. Group discussion lead to the following revision

of the text of the resolution, which was the version finally approved and adopted:

> ASIS and ALA, through their respective committees on education for information science, should endorse and support DISC (Developmental Information Science Curriculum) Project. This project's objectives would be to produce some kind of curriculum by means of a group effort.
>
> Other groups should be consulted and their endorsement of the idea sought (e.g., SLA, ACM, AFIPS, AALS, etc.) Nothing in this proposal shall prevent inclusion in this project at a later date of other interested organizations.

The interpretation of this resolution depends rather closely on the definitions of the key terms curriculum and group effort, as provided on p. 7 and 8 of this paper. Experimental tryouts of the materials would be arranged and feedback would be collected and used to improve the materials before their release, with the endorsement of the sponsoring societies, for general distribution.

- E. M.

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Source: Amarel, Saul. "Computer Science: A Conceptual Framework for Curriculum Planning." Communications of the ACM June 1971 Vol. 14 No. 6 p. 396.

Fig. 4. Structure of major areas of activity in computer science

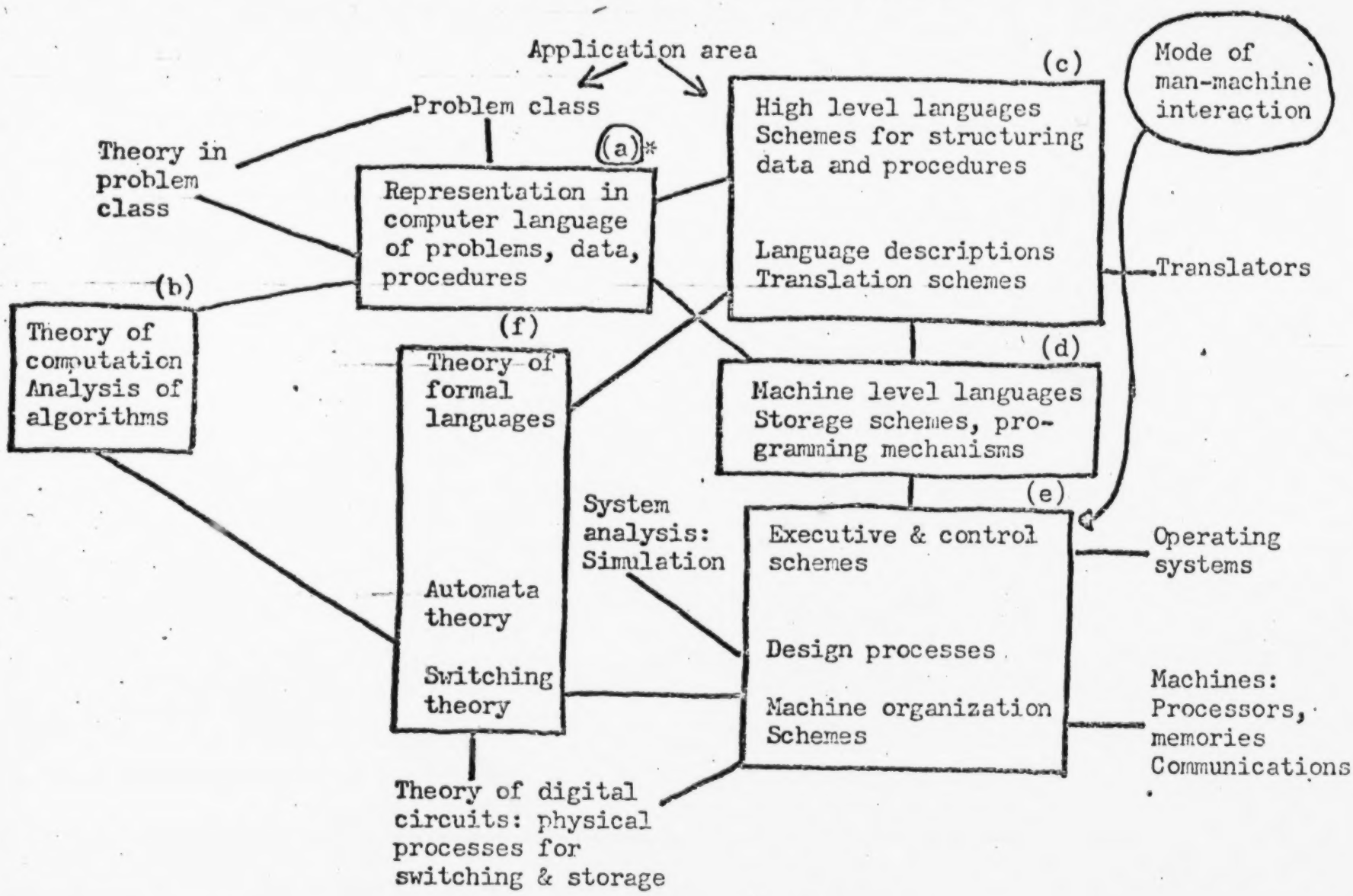

Fig. 5. Application areas from the viewpoint of computer science

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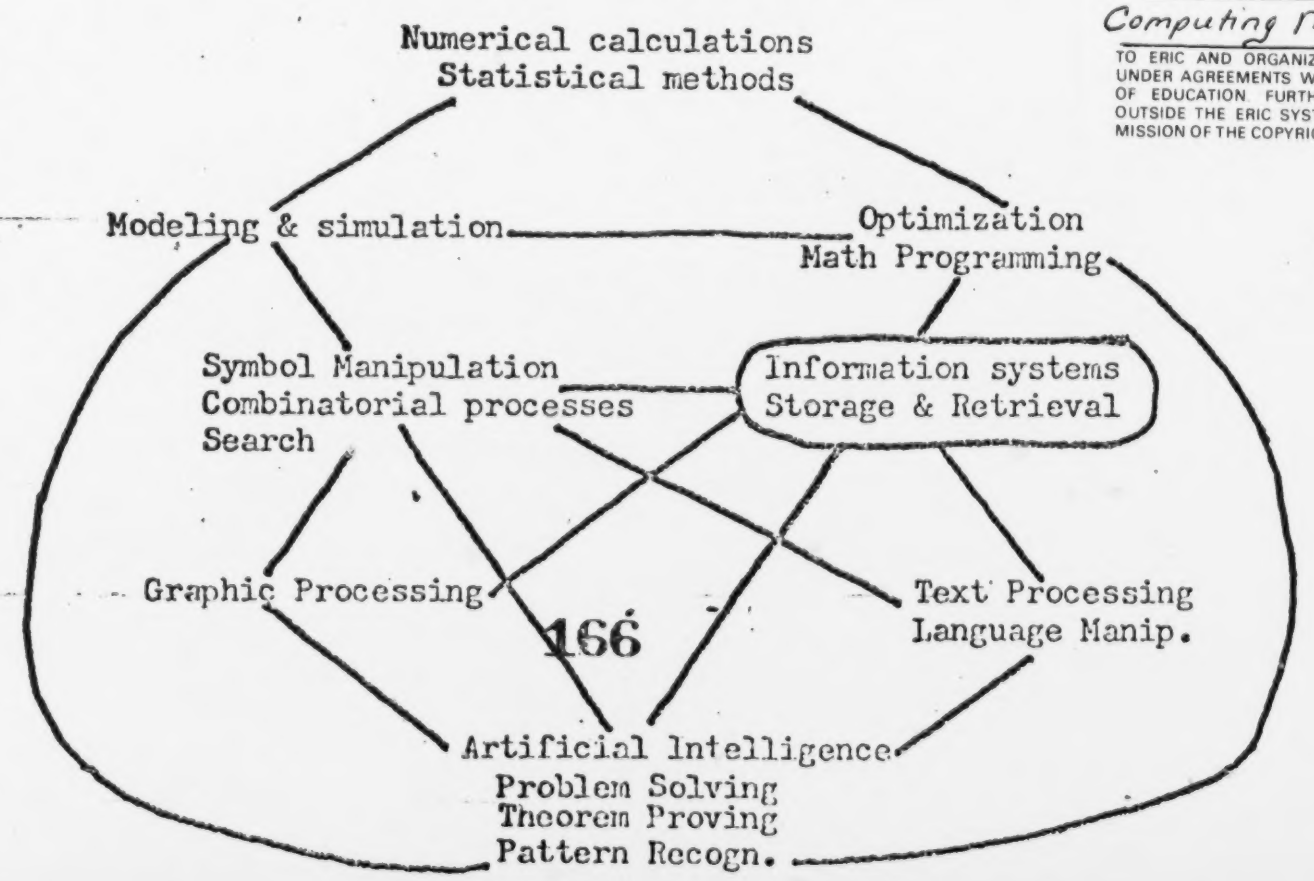

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FUTURE SHOCK: NOTES TOWARDS A SUMMARY AND DIRECTION

RUSSELL SHANK

A conference such as this is most difficult to summarize. We covered much ground, with little time devoted to each aspect of the development and directions of information science education. Hence, there was little time for issues, trends and underlying themes to heap up into critical masses that might serve as nodes in a summary.

Furthermore, I found my mind frequently being stimulated or provoked by an issue or a point, and while concentrating on my own inner colloquy as papers were being presented and discussed, I missed other significant items. But of even more serious consequence, my mind just does not comprehend relationships and meanings fast enough to provide what I consider instant playback. It was I that the editor of a journal recently had in mind when he wrote: "I know you believe you understand what you think I said, but I'm not sure you realize that what you heard is not what I meant." (Better Living, Fall, 1971).

We started with provocation, which is not unusual for a meeting of information scientists. I remember a New York meeting of the American Documentation Institute in the early 1950's at which Jesse Shera and the late Mortimer Taube stood on opposite sides of the room and argued quite different views about what "documentation" was--if indeed it was a thing apart. Unlike that earlier discussion, Vagianos was not searching his own mind anew for the definition of information science. He was telling us that our own words, recorded in our literature, show uncertainty and ambiguity about the nature and

content of information science, and even question that there is such a thing.

Naturally, some of us take umbrage with Mr. Vagianos. But no one very seriously addressed the issue Vagianos raised, and this was a flaw in our proceedings that must be remedied during the process of curriculum development recommended by the conferees. Someone during the conference said that if you don't know where you are going, then any road will take you there. But if we don't know where we are, how do we know that the roads to the reasonable destination even pass this way? Perhaps the unclear perception of what information science is explains the enigmatic treatment of the theoretical base of information science during the conference. We must agree upon some definitions or content for an information science before we can work on curriculum development to instruct in it.

I was considerably surprised that we dealt so little with the role of information science in the handling of the social issues we face today. Culture thrives upon communication through information systems. It is impacted by communications events. Much of the goodness and the illness in society may be attributed to communications events--their content, their speed, their quality, their ubiquitousness, and their susceptibility to manipulation to serve ends. We are faced with a revolution in telecommunications capabilities and we seem unaware of our potential role in influencing this revolution and using its products. I would urge you, therefore, to reread, and then try to think beyond Professor Parker's paper in these proceedings. Certainly our curricula must clearly reflect an understanding of the social consequences of the age of communications. (I will return to this notion later).

We ought also to ponder longer the meaning in the narrative by Lunin on the injection of an understanding of information process into the education of those entering other fields. We claim to know a considerable amount about the users' information needs, and their acquisition and use of information. It seems perfectly clear to me that we can enhance the viability of our field, and the status and impact of our practitioners, by making the study of information and data acquisition, handling and use a basic part of the education in substantive fields. The more others know about information as the raw materials with which we work, the more they may know how to, and want to, use us and our products when they go into practice.

It is not a bad idea, either, for us to do a little proselytizing as we work with undergraduates (or even graduates) in other fields. It has been of considerable benefit to information science that we have had to draw on talents from many fields to create our discipline. I believe we cannot afford to shut off this pipeline into us for new understanding of phenomena that are transferrable into the theoretical construct of information science. We will have a constant need to draw upon people from other fields who can translate seemingly irrelevant notions and theories into the grammer of information science.

I was most discouraged that Mr. Minder was not able to generate a solid and focused discussion of the theoretical base for information science. The understanding of theory is a high priority objective in education, and we will remain in what is a temporary or interim status until we have our theories of information science clearly in view, not only for our own guidance, but also to tell the world we serve what to expect of us.

Not only are we working without a theoretical base, but also we have an inadequate understanding of the market place. It is not enough to know that our graduates are employed. The question is, are they starting at the beginning to perform and do they grow intellectually, building on a logical base of useful knowledge gained in their education experiences? Or do the employers have to do a major retreading job on our graduates in order to have even a beginner in whatever jobs have been created?

I was encouraged, therefore, to hear one of the working groups discuss behavioral objectives as a guiding concept for creating appropriate curricula for information science. Our starting point as educators ought to be the question: what does the market place expect graduates of information science programs to do? An employer has the right to expect certain behavior or performance characteristics from graduates of our programs. We may not agree among ourselves as to which are the most appropriate combinations of characteristics. Perhaps there are many, and we must expect the diversity we find in educational programs in information science. Nevertheless, the rule of the game remains the same. An employer should be able to match the specifications of his beginning jobs in information science with the educational goals of our curricula in order to reach a high probability of success in locating programs that turn out people to fill real jobs. This, I am afraid, he cannot yet easily do. The diversity of course offerings, and the total package of education from our many programs present a view of a ramshackle enterprise. And while we didn't say it here, it is most difficult in many cases to fathom how some of our course offerings

contribute or relate to program objectives as stated in our catalogs.

I would, therefore, have expected a clear presentation by someone in our joint sessions of the need for the determination of objectives in terms of expected behavior of graduates as an early step in curricula planning--and this was missing. However, if we go on from here to do curriculum development work, following modern methods we will soon be engaged in such a determination.

One element missing from our deliberations, for which I am grateful, was an argument about the distinction between information science and librarianship. During a break someone said that the gap between the two has indeed narrowed. It is difficult to know just who has moved towards whom, but I would suggest that elements of both topical areas have enlarged towards each other. Information science has been good for librarianship--it has provided it with a construct for generalization of what librarianship and its elements are. I hope that some information science people have seen that librarianship generalized contains some wheels that do not have to be reinvented!

The gap seems to have narrowed, or perhaps the areas of understanding increased, between information science and computer science, and between the former and business administration. If Louis Vagianos were still here he might say that this proves that there is no such thing as information science--that it was always just elements of other fields. There is nothing wrong with creating a new discipline out of parts of dispersed fields, but if this is what we have done, then it is indeed time that we search the structure for the universals--the theories that underlie what we are calling information science. I think they are there, and

that the time is exactly ripe for stating them. Along with behavioral objectives, theories are required for the proper creation of curricula and the materials of education.

Our conference was focused on directions for information science education, and this suggests that "futures" are important to us. I have found Alvin Toffler's analysis of trends and futures of his book "Future Shock" to be most appealing and seemingly prescient. Not only that, but much of what Toffler says is or has happened to society, stems to a large extent from revolutions in communication and this brings us to the important influence on society of our own field of information science. As information scientists we should therefore be able more fully and more readily to understand and explain through exemplification Toffler's analysis.

But even without that, we should be able to benefit from his analysis in planning for the future. Much of what Toffler says can be taken as justification for the way we have put together education for information science. We may, therefore, have discovered quite by accident how to operate an educational program of the kind that Toffler suggests is required in order to create an environment to cope with influences that tend to lead to "future shock." But even more vital, one cannot fail to recognize in Toffler's analysis the potential of information science and technology to serve society in dealing with shock conditions.

Toffler's presentation has some of the sense of overkill--his points are made many times with as many examples from as much of life and society as he can find. But it is not difficult to get his message. This is a time of change--of diversity, of novelty and of transience.

And as change comes at us faster and faster, we have less and less time in which to make decisions as to how to react. Unless we can cope with this condition, we tend towards a state of shock--shocked by what the future is bringing to us, and by the rapid pace with which it is thrown at us.

So what does Toffler suggest that is so important to the development of educational programs in information science? It is Toffler's view that we must develop a strategy for dealing with the uncertainty of the future. As with cars speeding down a freeway towards an exit, we must learn to recognize the signs of what is coming much more rapidly than we used to when we proceeded at a leisurely pace towards an upcoming intersection. Somehow we mustenhance our sense of the future. Among other things we should pay as much attention in our educational environment to the future as we do to history. In today's school the study of the past and the elements of culture that come from the past, consumes considerable time. Examination of current events takes only a sliver of time. Quite usually, no time is spent on the future. We must lead young minds to imaginative exploration of issues that will confront them. This creative ability is required in order to cope with transcience, diversity and novelty.

To deal with the uncertainty of the future, education should be aimed at teaching people how to learn, how to choose, and how to decide. If we do this, then it becomes less important for us to guide students to knowledge at advanced levels through prescribed curricula--the choice of what to study, and in what sequence, for a degree can be left to the student. Toffler predicts the disappearance of course requirements for college degrees.

Even the very concept of a "course" becomes broader. The student of the future may not only wander away from a formal curriculum on a college campus, but also he will be shown ways to qualify for the status of a baccalaureate through a wider range of experiences than are offered by formal "courses".

I think we can stop short of anarchy in the student's meandering towards intellectual maturity. But Toffler's analysis does suggest that we may be on the right course in information science by having a wide range of courses, with fewer prescribed sequences, or more choice of sequences, that lead to a degree in information science. Our curriculum-development project may take us to an empty field if we insist on a tight structure and a limited view of what elements belong in our discipline.

Information scientists should be highly motivated by Toffler's view of the future. The extension of educational experiences away from the campus, the inclusion of a wider variety of non-traditional environments as classrooms (e.g. the settlement house, the government bureau, the factory) and the expansion of the use of museums, commercial theaters, art galleries, parks, libraries and other such educational agencies, greatly increase the importance of properly designed and efficiently used information systems, and communications facilities, and ubiquitous access to information and data. We are faced with the prospect of having to provide the manpower capable of integrating dispersed information resources into a utility accessible by many, or demand, with sufficient interactive capability to facilitate reinforcement. The structure of the information resources themselves may have to be rebuilt

to respond accordingly. This is our business, and it is towards an impact on this reconstitution of the educational experience of everyone that we should be aiming our information science professionals.

Smithsonian Institute
Washington, D. C.
March 24, 1972

Editorial Note: Mr. Shank's discussion was originally presented extemporaneously at the final session of the Symposium. The text that appears in this document was prepared post hoc by Mr. Shank.